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PROGRESS REPORT OF THE ALASKA INSECT PROJECT FOR 1948

Cooperating Agencies: Office of the Surgeon General; Bureau of Medicine and Surgery; Alaska Command; Office of the Quartermaster General; Engineer Corps; Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture

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C. S. Wilson - Alaska Army Entomologist Liaison

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R. I. Sailer - Leader
Kathryn Sommerman
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Maj. F. S. Blanton-Leader
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Equipment

C. N. Husman - Leader

To Assist as Needed

Sgt. Carl Sweeney
Cpl. Ernest Hackney
Pfc. Joe W. Daugherty
Pfc. Lyle W. Nielsen
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Pfc. Nick Hoffman
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Pfc. Duane Wyatt

Chief Pilots and Crew Chief

Capt. L. E. Larsen
Lt. L. O. Nelson
Lt. R. B. Carlson
Sgt. J. R. Hill

INTRODUCTION

The preliminary survey of insect problems in Alaska in 1947 indicated the need for further studies on biology, taxonomy, and control. This preliminary survey, however, provided the information necessary for planning a large-scale attack on the problems existing in the area. Plans for the 1948 program were submitted October 16, 1947, by the U. S. Department of Agriculture to the Army Committee on Insect and Rodent Control, and were accepted by this Committee and by the Alaska Command. Subsequently, a group met in Washington to make the final plans concerning supplies and personnel, and revise the detailed work program.

An advance party of six arrived in Alaska March 3, and a total of 40 persons was assigned to the project during the season. In addition, a number of pilots and crew chiefs were assigned as needed throughout the summer. Construction and servicing of airplane equipment was handled by Ft. Richardson personnel. The members of the project included 15 entomologists, 1 climatologist, 1 botanist, 1 laboratory technician, 1 aquatic biologist, 1 supply officer, and 1 equipment engineer. Nineteen enlisted men were assigned to the project for periods of 4 weeks to several months. Two of the entomologists, Mr. J. D. Gregson from Canada and Maj. W. C. Frohne from the U. S. Public Health Service, were with the group as liaison representatives. The control activities were coördinated with those of the Army entomologist in Alaska, Mr. C. S. Wilson. Quarters and subsistence were again made available to the group at the 183rd General Hospital. Most of the technical staff departed from Alaska the week of August 22 and the last of the group left October 27, 1948.

The foremost objectives of the program in 1948 were a detailed biological study of the biting fly fauna at a series of stations established in 1947 and 1948, collection of a larger series of reared specimens for taxonomic studies, and experimental control of mosquitoes and black flies with ground and aerial equipment. It was also planned to develop wing-boom spray equipment for the C-47 airplane which would enable efficient treatment of large areas in a minimum of time and at distances beyond the range of smaller aircraft.

The program of work as outlined was for the most part completed as planned. In a few cases the plans were altered to fit better the conditions encountered during the season. Populations of insects were adequate for the investigations, but towards the end of the season unfavorable weather interfered with work on several phases of the program.

The data obtained by the various sections are presented under appropriate headings in the report. Some of the outstanding findings and accomplishments may be listed as follows:

1. Developed spray-boom equipment for C-47 aircraft which had an effective swath width of 800 feet, thus enabling areas to be sprayed with less than half the flying required with the single vertical discharge pipe previously employed. With this equipment changes in application rates can be made during flight.

2. Demonstrated that with efficient airplane equipment satisfactory control of mosquitoes is obtainable with a dosage of only 0.1 pound of DDT per acre as compared with 0.2 to 0.3 pound with the standard gravity-flow equipment.

3. Determined that, because of long-range migration of adults from surrounding areas, larval control in a 30-square-mile block (in the Fairbanks area) was inadequate to protect a central community from adult annoyance.

4. Determined that effective adult control over 4 to 5 square miles provided protection for only 24 to 48 hours, and over 30 square miles for only 7 to 10 days, because of rapid adult infiltration from surrounding areas.

5. Demonstrated that black-fly larvae can be cleared from 1 to 2 miles of streams by one 800-foot swath across the stream with the C-47 equipment.

6. Determined that the present standard-issue repellents will provide effective protection against the attacks of Alaskan species of mosquitoes and black flies and that none of the newer repellents are outstandingly better than the standards.

7. Demonstrated that none of a large group of repellents were highly effective against punkies (Culicoides) at Valdez.

8. Obtained information which indicated that fish would not be affected adversely by the insecticidal treatments necessary for the control of mosquitoes and black flies in Alaska.

9. Obtained detailed biological and taxonomic data on the biting fly fauna of Alaska, which will be of immeasurable value scientifically, as well as in proper timing of control measures for maximum effectiveness.

10. Obtained data on the relationship of climatic factors to adult insect activity.

11. Contributed materially to local and military control programs in Alaska, including materials and equipment and the development of methods for use in future operations.

As was the case last year, various members of the U. S. Department of Agriculture, Office of the Surgeon General, Office of the Quartermaster General, and the Engineer Corps contributed much time and effort to the planning and execution of the Alaskan project. In addition, all personnel from all departments and bases in the Alaska Command were most cooperative and provided the project with all facilities, supplies, equipment, or personnel that were requested. Without the assistance given by these groups, the mission could not have been completed successfully.

So large an amount of technical information was gathered during 1948 that all of it cannot be included in the main report. A supplemental report will, therefore, be issued later to contain the detailed biological and taxonomic data.

SUMMARY

As a continuation of studies begun in 1947, a technical staff of 21 made intensive studies during this summer on the biology, taxonomy, and control of biting insects in Alaska. The personnel were specialists in the fields of entomology, aquatic biology, botany, climatology, equipment engineering, and supply. In addition, 19 enlisted men were assigned to the project for periods of about 4 weeks to several months. Two of the entomologists, Mr. J. D. Gregson from Canada, and Maj. W. C. Frohne from the U. S. Public Health Service, were with the group as liaison representatives. The large-area control activities were coordinated with those of the Army entomologist, Mr. Wilson.

The field work was initiated by the advance party who arrived in Alaska March 3 and all work except that of the biology section was completed by the week of August 23, 1948. Some of the biology section personnel remained in Alaska until late in October. The program as outlined was, for the most part, completed. Populations of insects were adequate for the investigations, but toward the end of the season unfavorable weather interfered with portions of the program.

Special commendation is due the Alaska Command. All departments and personnel were most cooperative, and the 1948 mission could not have been successfully completed without their willing assistance.

General Survey

Three general surveys were made during 1948. The first, during the last week of May, covered most of the highway system south of the Alaska Range and was concerned with the distribution and abundance of the various species of mosquitoes as larvae. The second trip was primarily concerned with the abundance and species of adult mosquitoes, although much information on the immature stages of black flies was also obtained. This survey, from July 9-25, covered virtually the entire highway system. The third survey, from August 22 to September 8, was concerned with the abundance of adult black flies and Culicoides and covered most of the highway system. Most of the streams visited in July were re-examined for immature black flies. In the course of these two trips about 1,000 adult black flies were reared from pupae. The Brooks Road to Livengood and the Willow Station Road west from Palmer were each covered once. Incidental observations were made at Naknek, Umiat, and Point Barrow.

Mosquitoes were abundant and very troublesome over most of the area lying north of the Alaska Range. In this area only the Tanana Valley above the Robertson River was found relatively free from troublesome populations. South of the Alaska Range populations were no greater and, in some areas, smaller than in 1947.

Adult black flies were abundant at Naknek about June 1 and along the first 60 miles of the Steese Highway on June 24. They were generally prevalent in small numbers over most of central Alaska during the last week of August and first week of September. At this time annoying populations were encountered at

mile 70 on the road to Nabesna and at Mentasta. They were generally most numerous along the Steese Highway and least numerous along the Alcan Highway from the Yukon Border to Big Delta. The black flies bit very rarely but considerable annoyance usually resulted from their landing around the mouth, nose, and eyes. Several local residents were interviewed who had been severely bitten, and two cases of serious annoyance to groups of men working along the highway were observed; however, there was no evidence during 1948 that black flies were a widespread pest problem as compared with mosquitoes.

Culicoides were encountered in small numbers at many localities in central Alaska and were generally aggressive biters. Valdez was the only locality where they were observed to be a pest problem. They were present here in great abundance from the middle of June until the city and surrounding area were sprayed the latter part of July. Troublesome numbers were observed on nearby tidal flats as late as August 25.

Horse flies were encountered in small numbers throughout central Alaska and caused some annoyance on the tidal flat near Valdez. No snipe flies were seen except in the vicinity of Valdez. They were aggressive biters but were not sufficiently numerous to cause much trouble.

Biology and Identification of Bloodsucking Diptera

Detailed studies of the biology of mosquitoes and black flies were undertaken during 1948. A series of stations representing breeding sites of these insects was established in the vicinity of Anchorage and another series in the vicinity of Fairbanks. These stations were visited at weekly intervals from the time of the spring thaw until practically all insects developed, and adult activity ceased in the fall. Much supplementary information was obtained from localities scattered throughout the portion of central Alaska which could be reached by highway. Emphasis was placed upon identifying the pest species and learning as much as possible about the source and development of pest populations.

Aedes communis was the most widely distributed and numerous species over the greater part of central Alaska. Aedes intrudens, A. punctor, and A. impiger were major contributors to the troublesome populations present in the Fairbanks area. In the Anchorage area A. punctor was more abundant than A. communis, and most of the population was composed of these two species. A. flavescens was abundant on one coastal marsh. Mosquito populations near Anchorage were localized and caused little trouble.

A pronounced, though overlapping succession of species took place throughout the season. Small second broods of Aedes communis and A. punctor were produced in the Anchorage area. It was not learned whether these hatched from eggs laid during 1948, or from eggs carried over from the previous season.

Of the black flies Simulium venustum, S. perissum and Prosimulium hirtipes were the most common throughout central Alaska. Simulium aureum, S. latipes, and Cnephia pallipes were also abundant in the vicinity of Fairbanks. All of these species, except P. hirtipes, were usually found in warm, slow to moderately swift, streams and occurred in greatest numbers in streams draining shallow lakes. Prosimulium hirtipes was usually found in clear, cold, swift

streams. As a result this species was particularly abundant in mountainous areas. Black flies were generally most numerous in late August and September; however, large populations were encountered in localized areas as early as the last week in May.

Of the Culicoides, tristriatulus and yukonensis appeared the most important species. The former was predominant in the coastal regions and occurred in greatest abundance at Valdez. C. yukonensis is distributed throughout central Alaska but was never observed in numbers sufficient to create a pest problem. C. tristriatulus was most numerous during the first half of July while yukonensis was encountered most frequently, and in largest numbers, during the last half of July and through August.

Thirty-six C. tristriatulus were reared from pupae and one adult was reared from a last instar larva. Rearing was undertaken too late to catch the main brood, but this species apparently breeds in shallow sedge and rush marshes which are flooded by high tides. The only larva reared came from muck under about an inch of water. Pupae were collected from the water surface at the same place.

No biological studies on horse flies or snipe flies were undertaken.

During the season 19 species of mosquitoes, at least 30 species of black flies, 5 species of Culicoides, 15 species of horse flies, and 1 species of snipe fly were collected. One of the mosquitoes, Aedes impiger, was not identified during 1947 but in 1948 was found to be one of the more important species both at Fairbanks and at Anchorage.

The mosquitoes were Aedes cataphylla, A. cinereus, A. communis, A. diantaeus, A. excrucians, A. fitchii, A. flavescens, A. impiger, A. intrudens, A. nearcticus, A. pionips, A. pullatus, A. punctor, A. stimulans, Anopheles occidentalis, Culex territans (reported as apicalis in 1947), Culiseta alaskensis, C. impatiens, and C. morsitans.

The black flies were Cnephia borealis, C. pallens, C. pallipes, Prosimulium fulvum, P. hirtipes, P. onychodactylum, P. pleurale, Simulium arcticum, S. aureum, S. corbis, S. costatum, S. decorum, S. latipes, S. perissum, S. venustum, S. vittatum, and at least 14 additional species which are either undescribed or for which names are uncertain. One new genus with two undescribed species is included.

The five species of Culicoides were C. biguttatus, C. obsoletus, C. tristriatulus, C. yukonensis, and one unnamed species.

The horse flies were Chrysops excitans, C. mitis, C. nigripes, Chrysozona americana, Tabanus affinis, T. astutus, T. epistates, T. gracilipalpis, T. illotus, T. liorhinus, T. metabolus, T. septentrionalis, T. sexfasciatus, T. tetricus hirtulus, and T. trepidus.

The one species of snipe fly collected was Symphoromyia atripes.

Mosquito Larvicide Tests

The relative effectiveness of several of the newer insecticides as prehatching treatments was determined from a series of 201 plots treated with hand equipment and 40 plots treated with airplane equipment. One plot of each treatment was located in each of five different mosquito-breeding environments. Half of the plots were treated in August 1947 and half in March and April 1948 when the snow was 3 to 30 inches deep. Hand plots were treated in the fall with 2.0, 1.0, 0.5, and 0.1 pound of DDT in emulsions, fuel-oil solutions, larviciding dusts, and wettable powders, and in the spring with 0.5- and 0.1-pound dosages. In addition, spring plots were treated with 0.05 and 0.01 pound of DDT in fuel-oil solution and as larviciding dusts. Chlordane and toxaphene were applied at 1.0 pound per acre in fuel-oil solutions. Benzene hexachloride was applied at 1.0 pound per acre in a fuel-oil solution of crude material (12 percent gamma), and as a wettable powder (6 percent gamma) at the rate of 0.5 pound of gamma, or 8.4 pounds of total dust, per acre. Methoxychlor and TDE were applied at the rate of 0.5 and 0.1 pound per acre in fuel-oil solutions, and parathion in fuel-oil solutions at the rate of 0.1, 0.05, and 0.01 pound per acre. The airplane plots were treated with DDT in the fall with 2.0, 1.0, 0.5, and 0.1 pound, and in the spring with 0.2 and 0.1 pound per acre. The standard 20 percent DDT-Velsicol-AR-50-fuel-oil sprays were used on all airplane plots. The degree of control was based on a comparison of the larvae per dip in treated and untreated plots.

Complete control was obtained only with 2 pounds of DDT per acre as an emulsion. A 90-percent or better control resulted in plots treated with DDT by hand applications in the fall with 2 pounds in fuel-oil solution, emulsion, and wettable powder; 0.5 pound in fuel oil and wettable powder; and 0.1 pound as an emulsion. Fall plots treated by airplane with 1 pound of DDT per acre averaged better than 90 percent control. In the spring treatments, only the 0.1-pound dosage of DDT in fuel-oil solution and 0.5 pound of TDE gave better than 90 percent control. The following gave 70 to 89 percent control: fall applications with hand equipment of DDT at the rate of 1 and 0.1 pound in fuel oil, 1.0 and 0.5 pound as emulsions, and 2.0 pounds as larvicide dust; fall application by airplane of 2 pounds of DDT in Velsicol-AR-50-fuel-oil solutions; and spring application with hand equipment of 0.5 pound of DDT in fuel oil and 0.5 pound of DDT as an emulsion, and 0.5 pound of gamma benzene hexachloride applied as a wettable powder. All other treatments gave less than 70 percent control.

DDT was more effective as fuel-oil solutions and emulsions than as dusts applied with 10-percent larvicide or with 50-percent wettable powders. There was no significant difference between fall and spring treatments, but there was a large difference in effectiveness in the various environments. The treatments were least effective in marshes containing the shrub, Myrica, and most effective in grassy depressions.

Comparative tests against Aedes larvae with fuel-oil solutions of TDE, methoxychlor, and DDT at 0.1 pound per acre gave 84, 82, and 88 percent control, respectively, in 48 hours. The control with DDT at 0.2 pound per acre was 97 percent and fuel-oil solutions of parathion at 0.025 pound, 66 percent. Low kill was experienced with an application of 0.1 pound per acre of TDE, methoxychlor, and DDT in a seepage marsh, the respective percent controls in 48 hours being 68, 48, and 52. Last year similar low kills were obtained in the seepage marshes.

Comparative tests with 5 and 20 percent DDT sprays applied with an L-5 plane were made on first to fourth instar Aedes larvae in 13 plots. Applications of 20-percent DDT spray to give dosages of 0.1 and 0.2 pound of DDT per acre gave average kills of 99 and 100 percent in 48 hours, as compared to kills of 95 and 91 percent, respectively, for these dosages applied in a 5-percent spray.

A marsh area of 30 square miles, with Ladd Field in the center, was sprayed with a C-47, using the 20-percent standard airplane spray. The general terrain was flat and marshy, with about half the area flooded. Six square miles of this area were treated with 0.1 pound of DDT per acre, and 24 square miles with a 0.2-pound dosage. The average kill in 48 hours for the 0.1-pound dosage was 89 percent and for the 0.2-pound dosage 99 percent. The low mortality at the 0.1-pound dosage resulted from a large larval survival in one end of the plot which was adjacent to a high moraine. The high-altitude flight which was necessary to clear the moraine, and a tail wind up to 13 m.p.h. caused the spray to be carried away from this end of the plot. In most of the rest of this plot complete mortality occurred.

Black Fly Larvicide Tests

Airplane applications of 20 percent DDT, Velsicol AR-50, and fuel oil sprays to streams caused complete detachment of black fly larvae for 1/2 to 2 1/2 miles downstream when dosages of 0.1 to 0.4 pound per acre were applied to 100- to 2,400-foot sections. Treatment of a 1,600-foot section at the rate of 0.1 pound per acre caused a 58-percent detachment of larvae at a point 7.5 miles downstream and the same dosage on a 2,400-foot section caused an 88 percent detachment 6 miles downstream, but no reduction resulted 11 miles downstream.

Comparative hand-application tests with acetone solutions of DDT, TDE, and methoxychlor, at the rate of 0.025 p.p.m. for 8 minutes to streams caused larval detachments of 97, 97, and 98 percent, respectively. A dosage of 0.0125 p.p.m. of parathion for 8 minutes caused a detachment of 17 percent. The test insects were fourth-instar Prosimulium onychodactylum and P. hirtipes.

In another series of tests complete detachment of fourth-instar hirtipes larvae was obtained with 6-minute applications of DDT at 0.3 p.p.m.

Control of Adult Mosquitoes

Large-scale spray tests in Alaska showed that mosquito adults infiltrate sufficiently fast into plots 24 to 30 square miles in area that the plots must be re-treated about every 7 to 10 days during the peak of the mosquito season. When only 4 square miles were treated, the infiltration of annoying numbers of mosquitoes occurred within 48 hours. Repeat treatments, even of the large area, were found necessary, and fair protection was obtained with four sprayings during the season. The mean initial reduction with dosages of 0.4, 0.1, 0.05, and 0.025 pound of DDT per acre were, respectively, 94, 86, 80, and 46 percent. Except for one test, which was applied under unfavorable wind conditions, the average reduction for the 0.1-pound dosage would be 92 instead of 86. The dosage of 0.1 pound of DDT is considered adequate if applied under suitable wind conditions.

Aquatic Biology

Tests with acetone solutions of DDT, TDE, methoxychlor, and parathion were made on the arctic grayling, _Thymallus signifer_. Fish of this species, 4 to 7 inches long, were seined from a small stream, exposed in metal troughs to various concentrations of the insecticides for 15 minutes, and then confined in screen cages placed in the stream. The water temperatures in all but two tests ranged from 47° to 53° F. DDT caused no disablement during the 15-minute test period, nor any kill within 24 hours at 60 p.p.m., but did result in 50 percent disablement and 30 percent mortality at 75 p.p.m. TDE caused no mortality at 80 p.p.m., but 40 percent disabling occurred at 75 p.p.m. in 64° F. water. Methoxychlor at 50 p.p.m. caused no mortality, but 50 percent mortality occurred at 35 p.p.m. Forty-five percent mortality resulted with parathion at 10 p.p.m. and none at 7 p.p.m. In tests with 20 percent Velsicol-AR-50-fuel-oil solutions of TDE or DDT applied at 20 quarts per acre, fish were unaffected after confinement in troughs for 2 to 3 hours. During this exposure the fish came to the surface frequently to feed on insects which were placed there for food.

Repellents and Protective Clothing

In field tests on mosquitoes the repellents, for comparative purposes, were applied to the skin as 25-percent solutions in ethyl alcohol in order to reduce the length of observation periods. Of 10 repellents tested, 6 were effective at this dilution for 113 minutes or more against _Aedes flavescens_, and 7 for 34 minutes or more against _A. excrucians_, _A. communis_, and _A. pionips_. Against _A. flavescens_, there did not appear to be any appreciable difference in effectiveness between Indalone, Rutgers 612, 4-(_p_-methoxyphenyl)-5-methyl-1,3-dioxane, 2,2'-thiodiethanol diacetate, and the standard 6-2-2 mixture. Propyl _N_,_N_-dipropylsuccinamate gave a much longer protection time (178 minutes) than any of the other five most effective repellents against _A. flavescens_. Against mixed populations of _A. excrucians_, _A. communis_, and _A. pionips_, dimethyl phthalate and propyl _N_,_N_-dipropylsuccinamate gave 94 and 92 minutes' protection time, respectively. This was well above the protection time afforded by the other 8 repellents against these species.

When cream preparations containing 20 percent of these 10 repellents were compared with the liquid form at 25-percent concentrations, it was found that the creams were slightly less effective. Full-strength liquids would be far more effective.

Against sand flies, none of the 10 repellents tested undiluted gave adequate protection. Only three, dimethyl phahalate, butyraldehyde, 2-ethyl-2-nitro-1,3-propanediol acetal, and the standard 6-2-2 mixture were effective for an average of 1/2 to less than 1 hour at full strength. The remaining seven materials tested were effective for 1/4 to 1/2 hour. The 6-2-2 mixture was superior to all others, providing an average of 49 minutes' protection, followed by dimethyl phthalate with an average protection time of 42 minutes.

In a series of tests in which 35 materials were tested for effectiveness when impregnated into fabrics, 10 were found to be effective after 4 rinsings and 16 hours of wear. Hexyl mandelate was the most effective, withstanding 13 rinsings and 40 hours of wear. The remaining 9 of the 10 most effective were very close together in protection afforded.

Tests with 6-, 8-, and 10-mesh close-fitting face masks impregnated with propyl N,N-dipropylsuccinamate, ethyl beta-phenylhydracrylate, dimethyl phthalate, and the standard 6-2-2 mixture were found to be ineffective against sand flies even though the number of bites was greatly reduced. The untreated, close-knit, head net afforded fair protection.

CLIMATIC STUDIES

The maximum and minimum temperatures of three streams were observed in connection with black fly studies. Little Otter Creek, which was formed in a bog, was found to be cool and had only a small range in temperature during the spring. Otter Creek, the outlet stream to Otter Lake, was found to be warmer and increased in temperature rapidly between April 25 and June 10. The outlet stream to Lower Fire Lake was similar to Otter Creek, but was much colder during the first 2 weeks.

A study was made of mosquito larval pools including an investigation of the vertical and horizontal temperature gradients of the pools as well as a comparison of temperatures of a number of different pools. Pool temperatures, even those covered or partially covered with ice, were found to be much warmer than had been anticipated. Pools whose temperatures rarely rose above 40° F. showed arrested mosquito development.

From records of adult mosquito activity in the vicinity of Fairbanks during June, it was found that activity decreased rapidly with increased wind velocities. There were three times as many adults when the wind was below 1 mile an hour as at 2 to 3 miles per hour. Activity also decreased rapidly when temperatures were above 80° or below 45° F. Except when temperatures at the 3-foot level were below 45°, inversion conditions caused a great increase in activity. Heat radiation and relative humidity appeared to influence mosquito activity only slightly.

A study was also made, in the vicinity of Valdez, of the relationship of _Culicoides_ activity with weather. In this study wind was found to be of primary importance. _Culicoides_ appeared unable to fly against a wind stronger than 3.5 m.p.h., but showed greatest activity with winds between 1.5 and 1.9 m.p.h. Activity decreased rapidly after temperatures fell below 50° F. and there was almost no activity below 45°. When the wind was below 3 m.p.h. activity was strongly influenced by light, being almost four times as great during sunlight as during darkness. Relative humidity, pressure tendency, and temperature lapse rate appeared to have only a slight effect on _Culicoides_ activity.

A number of detailed weather observations were made during the course of airplane spray tests to determine the most favorable meteorological conditions for the application of sprays. Excellent results were obtained under a wide variety of conditions, including very steep lapse rates, stable lapse rates, moderate wind, and even light rain. General climatological data were secured and weather forecasts were issued when requested for use in planning various control activities. Climatological conditions, particularly wind, temperature, and humidity, were recorded at each station during the July and August surveys to be used as an aid in evaluating the insect counts.

VEGETATION STUDIES

A few observations were made on the rate of development of plants and the stage of development of mosquito larvae. Also, detailed botanical studies were made of a number of the biology stations.

AIRPLANE EQUIPMENT

Wing-boom spray equipment was developed for a C-47, using B-29 electric fuel transfer pumps for the pressure system. Five pumps were installed, each of which would deliver 14.3 gallons per minute, equivalent to 1/2 pint of spray per acre for a swath of 800 feet. Swath-width and droplet-size calibrations were made with the three planes assigned to the group, using the 20 percent airplane spray, delivered at the rate of 1 pint per acre. The C-47, flown at 140 m.p.h., gave a droplet size of 136 microns mass median diameter. The UC-64, or Norseman, flown at 120 m.p.h., gave a 300-foot swath and a droplet size of 156 microns m.m.d. Droplet size in microns from the L-5 with impinging plate was 98 m.m.d., and without the plate, 224 m.m.d. A check valve was installed on this plane to prevent the drainage of the spray booms.

BLOWFLIES AND ECTOPARASITES COLLECTED

Fly trap collections of blowflies were made at Fairbanks and at Anchorage, with liver and fish as bait. Eight species were taken, and of these *Protophormia terrae-novae*, *Calliphora terrae-novae*, and *Lucilia illustris* were most abundant.

A number of small mammals were examined for fleas and ticks. A total of 13 species of fleas and 1 species of tick were collected.

GENERAL SURVEY

R. I. Sailer, B. V. Travis, S. Lienk, G. J. Daley,
B. L. Morris, M. Ridenour, and L. Dover

During the 1948 season survey activities were restricted primarily to the Alaskan highway system. Observations were also made by Project members during visits to Umiat, Point Barrow, and Naknek.

Most of the highway system was covered twice and a considerable portion a third time during the season. Survey objectives were twofold. The first was to learn as much as possible about the abundance of mosquitoes, black flies, and Culicoides, as well as the extent of annoyance resulting from their activities. The second was the gathering of material and data which would provide information on the distribution of species and also supplement the biology studies conducted in the Anchorage and Fairbanks vicinities. A trip from Fairbanks to Circle City, June 24-25, was undertaken primarily for the purpose of learning whether the streams running parallel to this road might be suitable for larval black-fly control research.

It was hoped that a quantitative comparison of adult mosquito populations might be made by taking counts at locations where counts were made last year. Several variables made this virtually impossible. Perhaps the most important factor was time of year, the adult counts being made in 1948 a week to 10 days later than those of 1947. The 1947 stations could not be visited at the same time of day and, furthermore, counts could not be checked against the wind factor, since no wind records were taken in 1947.

There is no question, however, that mosquito populations were generally higher than those observed in 1947. A possible exception was the Nabesna Valley where a lower population is indicated by a comparison of counts and the experience of Project members who visited the area in 1947. The rest of the area south of the Alaska Range had scattered populations as high or higher than in 1947. North of the Alaska Range it was "a mosquito year". Judging from reports received from Umiat, Skull Cliffs, and Barter Island, this situation prevailed to the arctic coast. Only the portion of the Tanana Valley above the Robertson River seems to have escaped a generally troublesome population of mosquitoes. Throughout June and well into July landing counts of 40 to more than 100 per minute were the rule under optimum conditions in the lower Tanana Valley and along the Steese Highway as far north as Circle City.

The highest populations of black flies were observed at Naknek around May 1, along the Steese Highway from mileposts 25 to 60 during the day of June 25, and near Mentaska on August 29. Although large numbers would be flying around and many actually crawling on persons, practically no bites were suffered. This continued to be the case throughout the season. The August 22-September 8 survey party encountered black flies at 27 stations where the landing count was in excess of 4. The four men comprising this party suffered a total of only 5 bites during the trip.

During the August-September survey, three people were interviewed who had recently been bitten by black flies. One man at Eureka Lodge had a serious hand infection which had been initiated by a black-fly bite. Another man encountered at Sourdough Lodge had been badly bitten on the forearms while dressing a moose. He commented that they seemed to bother only the parts of his arms which had been smeared with moose blood. At Northway, Alaska, two carpenters told of having been annoyed by black flies 2 days before our visit. They were working side by side and one man was bitten severely on the forearms and lower legs. The other man was not bitten even though the black flies had caused considerable annoyance by crawling into his nostrils and eyes. The man who was bitten had dark skin and considerable hair on his arms and legs. The other man had light skin and scant hair on his arms.

Three other cases of black-fly annoyance came to our attention during survey activities. An Alaska Highway Commission road crew was annoyed and suffered some bites on July 9 at Sheep Creek, milepost 18.6, on the Richardson Highway. An Army engineer unit working at milepost 37 on the Richardson Highway suffered considerable annoyance from crawling and biting of black flies on August 26. On September 8 the proprietor of the Chicaloon Lodge told of sheep hunters who had been badly bitten by a "yellow fly" in Carbon Creek Canyon. Two of the men had eyes almost swollen shut and all had been bitten. Prosimulium fulvum would seem to be the only species fitting the description, and was the species causing most annoyance at Sheep Creek on July 9.

It was the experience of the survey parties that Culicoides caused more annoyance than black flies. While Culicoides were generally much less numerous than black flies, individuals present never lost an opportunity to bite. At Valdez, the Culicoides were a serious pest problem most of July and were still present in numbers outside the city during the last week of August. During July, dock workers were forced to wear head nets and gloves during times of peak flight activity. People living in the city seldom attempted to work in their gardens and yards during these periods. During the first 2 weeks of July, counts on hats of 300 to 500 were not uncommon on the tidal flats west of the city. While the population was greatest along the tidal flats, considerable numbers occurred up the valley as far as Sheep Creek. Culicoides were encountered at 11 of 141 stations visited during the general survey from August 22 and September 8.

Tabanidae were encountered in some abundance at Circle City on June 26, and on the tidal flats at Valdez July 7. Nowhere were they aggressive biters.

Snipe flies were often encountered on the dried-out wash plain near Valdez. In general, they were more aggressive biters than the Tabanidae.

Survey Trips

The May 25-31 survey covered the Glenn Highway, the Big Timber-Nabesna Road, the Slana-Tok Road, and the Richardson Highway from Glenn Allen to Valdez. The first station was at mile 63 on the Glenn Highway. With the exception of 6 stations south of Thompson Pass, all were located on or in the approaches to the plateau lying between the Alaska and Chugach Mountain Ranges. Seventy-five mosquito breeding areas were examined and the following species of larvae were collected and identified. The number of times the species was collected, together with the total number of specimens, is believed to provide an indication of relative abundance.

Species	Collections	Total Specimens
Aedes communis	45	666
A. punctor	26	199
A. impiger	20	251
A. pionips	17	62
A. pullatus	15	93
A. stimulans	8	32
A. cataphylla	8	27
A. fitchii	5	18
A. excrucians	7	15
A. intrudens	1	7
A. diantaeus	2	6
A. cinereus	2	2
Culiseta morsitans	1	1 (2nd instar)

From the results it appeared that Aedes communis is by far the most important species throughout the region, with A. punctor in second position. While more specimens of impiger than punctor were collected, the latter was found at a larger number of stations. In addition, punctor is a later species and the smaller larvae would have less chance of being included in the samples. Aedes pionips and A. pullatus would seem to fall in fourth and fifth positions, being represented almost an equal number of times.

Larval development was fairly uniform, with fourth instars and pupae generally present. None more advanced than third instar was found along a 20-mile strip in the Chugach Range, north of Thompson Pass.

Aedes communis was collected only once in the valley south of Thompson Pass and these specimens are not typical since the comb scales are acute at the apex. Otherwise, the proportional distribution of species did not seem to vary significantly.

Carex was the most common, and very often the dominant, plant associated with breeding pools.

Adult mosquitoes were not annoying during this survey except at overnight camps. At these places Culiseta impatiens and C. alaskensis were definitely annoying. On May 28, Aedes adults were troublesome at a camp near Slana.

Many streams were examined along the route of the May survey, and samples of black fly larvae and pupae were collected wherever found. Streams were generally at flood stage and difficult to work. Many that were examined proved to be either dry washes or intermittent streams later in the summer.

One survey trip was undertaken on June 24-25 primarily for the purpose of learning whether any of the streams parallel to the Steese Highway might be suitable for black-fly control studies. Observations were made and collections taken from most of the streams crossed and from several parallel streams. Larvae were prevalent everywhere but pupae were scarce. Practically all streams were cold and swift.

During the afternoon of June 24, adult black flies were abundant at every stop north of Pedro Dome until dusk near mile 60. On the following day, under identical weather conditions, no adult black flies were observed at any point north of 12-mile Summit. No pupae or pupal cases were present in any of the streams examined so the source of the adult population was not discovered.

Mosquitoes were present everywhere in most annoying numbers, counts of 60 to 80 being the rule. At stops after sunset, mosquitoes were often present in numbers probably exceeding counts of 120.

In the July survey (July 9-25) the entire highway system north of Anchorage was covered except the Livengood and Willow Station roads. Counts were made of mosquito and black-fly landings on the front and back of two men during a 68-second period. Local weather and other conditions were noted in some detail. Wind was measured by means of a hand anemometer, and humidity by means of a Friez hand-aspirated psychrometer. Mosquito populations were declining very rapidly during this period and July 25 was virtually the end of the mosquito season. Moderate populations were generally prevalent, but significantly low numbers were noted along the Richardson Highway south of milepost 90, in the Chitna, Nabesna, and Matanuska Valleys, and the Tanana Valley, above Robertson River. High populations were observed along the Steese Highway generally, particularly beyond mile 100, in the entire Tanana Valley below the Robertson River, along the first 50 miles of the Big Timber-Slana Road, and the Tok cut-off from Slana to north edge of the Alaska Range.

Adult black flies were nowhere troublesome. The largest number were encountered at mile 1377.5 on the Alcan Highway. Here, on July 15, there was a landing count of more than 100. Black flies were encountered at 64 of the 173 stations where counts were made.

Culicoides were seldom encountered except at Valdez and vicinity where they were abundant at the time of the first visit on July 3 and continued to be troublesome through July.

Thirty-eight stations, scattered throughout the area, were examined for mosquito larvae which were present in 24. The average was only 1 or 2 per dip, but Culiseta alaskensis was encountered in some numbers on occasion. The following list shows the species taken and gives an indication of relative abundance:

Species	Number of Stations	Total Specimens
Culiseta alaskensis	11	137
Culex territans	11	93
Anopheles occidentalis	6	35
C. impatiens	4	26
Aedes pullatus	2	4
A. pionips	1	8
C. morsitans	1	4
A. punctor	1	1

No immature Aedes, or Culiseta were collected in or north of the Alaska Range. Anopheles occidentalis was collected near the Alaska-Yukon boundary at mile 1225 on the Alcan Highway.

Black fly larvae and pupae were collected at almost every stream and approximately 500 adults were reared from isolated pupae. All streams were described and information assembled for the purpose of drawing up a more accurate and complete strip map.

Weather was generally favorable for insect activity, and bed nets were used at all over-night stops. The effect of constant mosquito annoyance was noticeable on all members of the four-man party. Little or no repellent was used because of its possible effect on the standard landing counts. Head nets were generally worn, but without covering the face except at stops where counts exceeded about 20.

The road from Fox to Livengood was covered on July 30 and 31, and the road from Palmer to Willow Station on July 31-August 1. These trips were primarily concerned with immature black flies. The results of all survey work dealing with immature black flies will be included in the section on biology. On neither of these trips were adult mosquitoes or black flies troublesome.

The last survey trip, from August 22 to September 8, covered the same highways as the July survey. Adult mosquitoes caused annoyance only at Berry Creek at mile 1377.5 on the Alcan Highway. The count was zero at all but 5 of the 141 stations visited.

Black flies were encountered at 54 of 141 stations as compared with 64 of 173 stations in the July survey. The only annoying numbers were encountered at mile 70 on the Nabesna Road and at Mentasta on the Slana-Tok Road. In general they were most numerous along the Steese Highway and least numerous along the Alcan Highway from the Yukon border to Big Delta. Four men suffered a total of only five bites during the trip.

Culicoides were encountered at 12 of 141 stations and were always aggressive. They were still abundant along the Valdez tidal flats, counts at the peak of activity reaching 200. Local residents agreed that the late July spraying had been very beneficial. Weather through much of August, however, was adverse to Culicoides activity and it was also reported that the population normally declined after the middle of July.

Culiseta and *Culex territans* larvae were found at four stations south of the Alaska Range. No mosquito larvae were found north of this range.

One hundred seventy-two stations were examined for black fly larvae and pupae, and about 600 adults were reared from isolated pupae. The pH value of most streams was also taken.

The weather was generally unfavorable for insect activity during this survey. Heavy snow was encountered on August 22 from mile 90 to 128 on the Glenn Highway. Snow was encountered again on August 30 from mile 50 on the Tok cutoff and continued while the party traveled down the Alcan to the Yukon line and back to Northway. Black fly activity occurred during favorable weather. Considerable numbers were observed near mile 70, Nabesna Road and Mentasta, as well as along the Steese Highway, during fair, warm weather. Below-freezing temperatures were encountered during the night of August 22 at mile 128 on the Glenn Highway and again during the night of September 4 at mile 70 on the Steese Highway.

A summary of the survey data showing the correlation of mosquito and black-fly activity with temperature and wind velocity is given in the following section, but the detailed landing counts and weather data for the two major survey trips will be made available later in a supplemental report, together with detailed records on the biology of these insects.

Correlation of Weather Factors with Insect Activity

Mosquito Counts During July Survey.--The temperature, humidity, and wind velocity, as well as general weather conditions, were recorded at each station where landing counts were taken. The correlation of mosquito activity with wind velocity and temperatures, based on 173 observations, is shown below.

Wind Velocity

Velocity, m.p.h.	Number of observations Total	Number of observations : Number positive	Total number of mosquitoes counted	Average count
0.0	54	44	1,154	26
0.1-0.4	47	36	792	22
0.5-0.9	34	30	532	18
1.0-1.4	9	7	62	9
1.5-1.9	10	6	63	9
2.0-2.4	11	8	104	13
2.5+	8	5	60 1/	12
Total	173	136	2,767	20.3

1/ A count of 9 at a maximum wind velocity of 6 m.p.h.

Temperature

Degrees F.	Number of observations Total	: Number positive	Total number of mosquitoes counted	Average count
45-49	3	3	5	2
50-54	19	13	124	10
55-59	31	14	150	11
60-64	26	21	465	22
65-69	41	35	866	25
70-74	33	32	732	23
75-79	14	12	224	19
80+	6	6	201	33
Total	173	136	2,767	20.3

Black-Fly Counts During August-September Survey.--Considerable meteorological data associated with black-fly landing counts were accumulated during the survey from August 22 to September 6. An analysis of these data provides some indication of the effect of certain climatic factors on the activity of adult black flies. Tables 1, 2, and 3 summarize the results for wind, temperature and time of day. Records taken at the Valdez Culicoides observation station are included, and since these records are based on observations taken at regular intervals at one location, they have greater significance than the remaining survey records. The individual counts at Valdez are shown in table 4.

As with mosquitoes and Culicoides, wind is obviously a critical factor governing black-fly activity. By far the greatest activity occurred at wind speeds of 0.0 to 0.5 miles per hour, although some activity was recorded at wind speeds up to 5.5 miles per hour.

Activity occurred between 46° and 61° F., and the highest landing counts were recorded at 59°. This upper limit probably reflects the generally cool temperature of the observation period rather than a true upper limit for black-fly activity.

Flight activity was observed to occur between the hours of 0700 and 1900. Highest survey landing counts were recorded in the afternoon during the hours of 1500 and 1600. No flight activity was recorded at Valdez during these hours, probably because of wind conditions. Peaks of activity at Valdez coincided with the periods of calm which occurred twice a day as the wind changed from off to on or on to off shore.

Humidity records are not shown but, in general, somewhat greater activity occurred at lower humidities which usually coincided with higher temperatures.

Local residents expressed the opinion that "white sox are always worst just before a snow storm." This was actually observed during the August-September survey. Three heavy flights of black flies were encountered during the trip and on each occasion rain and snow followed within 12 hours. This phenomenon was undoubtedly due to the warm, quiet period that usually precedes a storm front.

Table 1.--Black-fly counts at different wind velocities in the August-September survey.

Wind velocity (m.p.h.)	General survey: Number of observations: Total	Positive	Total counts	Average	Valdez: No. of positive observations	Average per count
0	16	10	102	10.2	--	--
0.1-0.4	24	16	145	9.1	--	--
.5-0.9	17	8	16	2.0	--	--
1.0-1.9	24	11	60	5.5	4	6.2
2.0-2.9	21	4	19	4.8	6	8.0
3.0-3.9	16	4	16	4.0	2	3.5
4.0-4.9	10	1	32	32.0	--	--
5.0+	13	0	0	--	2	2.5
Total	141	54	390	7.2	14	6.1

Table 2.--Black fly counts at different temperatures in August-September survey.

Temperature (°F.)	General survey: Number of observations: Total	Positive	Total counts	Average	Valdez: No. of positive observations	Average per count
Below 44	20	0	0	--	--	--
44-46	25	1	2	2	1	7.0
47-49	21	9	52	5.8	2	5.0
50-52	21	13	82	6.3	2	4.0
53-55	23	10	52	5.2	4	3.8
56-58	17	13	105	8.1	4	10.5
59-61	14	8	97	12.1	1	4.0
Total	141	54	390	7.2	14	6.1

Table 3.--Black-fly counts at different times of day. August-September survey.

Hour of day	General survey: No. of observations: Total	Positive	Total black flies	Average	Valdez: No. of positive observations	Average per count
7-9	21	5	26	5.2	5	8.8
10-11	27	8	44	5.5	2	4.0
12-13	23	10	69	6.9	2	2.0
14-15	35	18	113	6.3	1	4.0
16-17	26	12	137	11.4	3	8.0
18-19	9	1	1	1	1	2.0
Total	141	54	390	7.2	14	6.1

Culicoides Counts at Valdez on August 25, 1948.--The survey party arrived at Valdez on August 23 and found a fairly large population of _C. tristriatulus_ still present on the tidal flats. Certain climatic factors had undergone seasonal changes since the termination of the July studies of _Culicoides_ activity. The principal changes were the much shorter day and generally cooler temperatures. Darkness was complete for at least 6 hours and the highest temperature recorded was 62° F. The flats were covered by frost during the night of August 23. The observations taken on August 25 are summarized in table 4.

Generalizations based on only 1 day's observations are necessarily uncertain; however, the day was fair and representative of the best late summer weather. It will be noted that the periods of activity were sharply confined to two 3-hour periods, one in the morning and one in the late afternoon. Maximum activity in both instances was restricted to less than 30 minutes. The morning activity coincided with the wind shift from off to on shore and a sharp rise in temperature. The on-shore breeze was accompanied by a sharp drop in temperature and activity immediately decreased, ending completely as wind velocity increased. A decrease in wind velocity at 1200 was accompanied by a landing count of four specimens. The afternoon period of activity again coincided with the wind shift, this time from on to off shore. The count increased rapidly as wind velocity fell below 3 m.p.h., but dropped abruptly when the temperature fell below 49° F.

Table 4.--Observations at Valdez on August 25 on activity of punkies (_Culicoides_) and black flies.

Hour	Temperature	Wind (m.p.h.)	Landing counts: Punkies	Landing counts: Black flies
0700	46	1.1	0	0
0715	48	1.1	22	0
0720	49.5	1.0	0	0
0730	53	2.8	200	8
0735	47.5	1.7	175	0
0800	46	2.4	26	7
0900	48.5	2.8	11	8
1000	50.0	2.8	4	4
1100	50	3.4	0	4
1200	54	1.9	4	1
1300	55	3.8	0	3
1400	62	5.4	0	0
1500	58	5.4	0	0
1600	57	7.4	0	0
1700	55	5.3	0	0
1709	56	5.3	1	2
1723	55	5.5	1	3
1800	53	5.4	2	0
1845	53	3.4	3	0
1900	53	2.4	30	0
1930	49	1.5	200	0
1950	49	1.3	28	2
2010	47.5	1.2	22	0
2030	47	1.1	19	0
2105	46	1.1	0	0

BIOLOGY AND IDENTIFICATION OF THE BLOODSUCKING DIPTERA

The records on the habits and distribution of mosquitoes and black flies were so voluminous that only a general summary will be given in the present report. The detailed data will be presented in supplementary reports. The subsections on Culicoides, Tabanidae and Rhagionidae, however, will contain a more or less complete summary of the information obtained. The rearing of isolated larvae to provide material for taxonomic studies occupied a great deal of time of the biologists. The personnel also cooperated in the study of pool temperatures and the relation of climatic factors to mosquito activity.

Mosquitoes (Culicidae)

R. I. Sailer, S. Lienk, K. M. Sommerman, E. P. Marks,
C. O. Esselbaugh, G. Jefferson, M. Ridenour, and L. N. Dover

The biological studies undertaken during 1948 were a continuation of the preliminary studies initiated by the Alaska Insect Project in 1947. Parallel studies at Anchorage and Fairbanks were conducted to provide the following information:

1. Species composition of the mosquito population in each region.
2. Biology of the species concerned.
3. Comparison of the populations and habits of the species in the two regions.

The Anchorage laboratory was situated on the grounds of the 183rd General Hospital at Ft. Richardson. Biology stations representing different types of breeding conditions were located southwest, north, and northeast of Anchorage and covered a linear distance of 40 miles along the Knik Arm coastal region.

The Fairbanks laboratory was located at Ladd Field, and stations were located up to 30 miles southeast and up to 9 miles west of Fairbanks. Additional stations were located in the hills north of Fairbanks along the Steese Highway to the vicinity of Fox.

During the summer of 1948 a serious mosquito problem developed at Fairbanks and throughout neighboring portions of the Tanana Valley. At times of favorable flight activity mosquitoes were present everywhere in annoying numbers. Furthermore, the population was fluid and capable of wide dispersal. After adults were greatly reduced by aerial spraying over an area of 30 square miles, reinfestation occurred within a week.

At Anchorage mosquitoes did not present a general problem, and few were encountered in areas where human activity was concentrated. Troublesome numbers could be encountered, however, on any of the coastal marshes and in the vicinity of inland swamps and bogs. These populations were not observed to disperse far.

The species of mosquitoes found at Fairbanks and those found at Anchorage are listed below, arranged in the approximate order of importance based upon the extent of breeding area and observed larval abundance. At Fairbanks the first four species in the list, _Aedes communis_, _A. intrudens_, _A. punctor_, and _A. impiger_, were abundant. At Anchorage, _A. punctor_ headed the list in numbers found and _A. communis_ was second in importance.

Fairbanks	Anchorage
1. Aedes communis	1. Aedes punctor
2. A. intrudens	2. A. communis
3. A. punctor	3. A. impiger
4. A. impiger	4. A. pionips
5. Culiseta alaskensis	5. A. excrucians
6. Aedes excrucians	6. Culiseta impatiens
7. A. stimulans	7. C. alaskensis
8. A. fitchii	8. Aedes flavescens
9. A. diantaeus	9. A. diantaeus
10. A. pionips	10. A. cinereus
11. A. cinereus	11. A. fitchii
12. Anopheles occidentalis	12. Anopheles occidentalis
13. Aedes cataphylla	13. Aedes intrudens
14. A. flavescens	14. A. cataphylla
15. Culiseta impatiens	15. Culex territans*
16. Culex territans*	16. Culiseta morsitans*
17. Culiseta morsitans*	

* Not known to bite man.

A comparison of the salient features of mosquito development at Fairbanks and at Anchorage is shown below:

	Anchorage	Fairbanks
Date of first hatch	April 9	May 7
Main hatch	April 24-May 5	May 8-12
Date of earliest 4th instar	April 28	May 18
Greatest abundance of fourth instars	May 15-June 15	May 24-28
Date of last observance of 4th instar Aedes	October 2	July 15
First adult Culiseta alaskensis	April 8	May 9
First adult emergence (laboratory)	May 10	May 20
Period of greatest adult abundance	May 28-Aug. 1	June 3-July 15
Date of last observed adult activity	October 8	September 3

Principal habitats:

Fairbanks:

Temporary pools and potholes of snow-melt origin, located in areas where Carex and (or) Calamagrostis are the predominant or characteristic vegetation.

Anchorage:

1. Temporary to semipermanent pools and potholes of snow-melt origin but maintained to greater or lesser extent by seepage or by the water table. Carex, Calamagrostis, Potentilla, and Sphagnum, either individually or in combination, form the predominant vegetation of this type of breeding area.

2. Coastal marshes where Carex, Calamagrostis, or Potentilla grow in association with Myrica gale or trailing Salix.

3. Tidal flats where Triglochin maritima is predominant and usually associated with Scirpus.

Density of larval populations:

Fairbanks:

Population of low density but widely distributed. An average of 45 larvae per square foot in undisturbed habitats.

Anchorage:

Very dense population in restricted habitats at scattered localities. An average of 200-500 larvae per square foot.

A succession of species was observed at both places. At Anchorage the succession was easily followed within individual pools and by population averages; however, overlapping was more extensive and of longer duration than at Fairbanks. A small, second brood of A. communis and A. punctor developed in the vicinity of Anchorage during August and September. In general, the species fell into three seasonal groups: (1) Aedes impiger, A. intrudens, and A. communis. Intermediate, A. punctor. (2) A. cinereus, A. diantaeus, A. stimulans, A. pionips, A. excrucians, A. fitchii, and A. flavescens. (3) Culiseta morsitans, Anopheles occidentalis, C. alaskensis, Culex territans, and Culiseta impatiens. Judging from survey data, Aedes pullatus and A. nearcticus fall into the second group on seasonal occurrence.

Mosquito abundance appears to be closely associated with the amount of precipitation during the 8-month period from October 1 through May 31. In 1948 the spring thaw at Anchorage preceded that at Fairbanks by almost 1 month; however, by June 1 mosquito development at Fairbanks was less than a week behind that at Anchorage. As a natural result snow accumulation was a critical factor at Fairbanks while at Anchorage the mosquito population was greatly influenced by rainfall during April and May.

Average precipitation at Fairbanks from October 1946 through May 1947 was 6 inches (a deficiency of 1 inch), and no mosquito problem of importance developed during the summer of 1947. Precipitation from October 1, 1947 through May 31, 1948, was 7.4 inches, and the summer of 1948 was marked by a large and troublesome mosquito population throughout the Fairbanks area.

At Anchorage the average precipitation for the October through May period is 7 inches, but for this period in 1947-48 there was a deficiency of 1.7 inches. The months of April and May 1948 were unusually dry, having only 0.13 inches of precipitation compared with a normal of 1 inch. Observations at the Anchorage biology stations indicated that at least 90 percent of the hatching larvae were lost during May as a result of pool drying. This high loss of larvae undoubtedly accounted for the very low mosquito population present in the Anchorage area during 1948.

Black Flies (Simuliidae)

K. M. Sommerman, R. I. Sailer, C. O. Esselbaugh, S. Lienk, L. N. Dover, E. P. Marks, G. Jefferson, and M. Ridenour

The 1948 black-fly investigations closely paralleled those on mosquito biology. A great deal of effort was directed toward recognition of the species in their immature stages, which was necessary before biological information on the various species could readily be obtained. Survey observations provided much information concerning the distribution and abundance of black flies in central Alaska.

Black fly biology stations included 13 streams in the Fairbanks area and 16 near Anchorage. Two of the Anchorage streams had two or more stations located along their course, and this provided a comparison of different longitudinal sectors of the same stream. The period of study at Fairbanks began May 11 and ended September 13. The study period was somewhat longer at Anchorage, beginning April 14 and ending October 26. The stations were visited at weekly intervals and records taken of larval and pupal abundance as well as stream temperature, level, velocity, pH, and turbidity.

Survey activities covered almost the entire central Alaska highway system, and observations were made at 290 locations. Most of these were visited twice, and many three times during the season. Observations at survey stations were the same as those made at biology stations. Pupae were collected and individually reared during the July and the August-September trips. A total of 864 adult black flies associated with pupal skins were thereby obtained. These, together with adults reared individually from pupae collected at the Fairbanks and Anchorage biology stations, are expected to be of much help in taxonomic studies.

Tables 5, 6, and 7 are based on tentative identification of immature stages. Much taxonomic work must be done before the status of the unidentified material can be clarified. The letters and other symbols shown in parentheses were ones used in manuscript notes and labeling of material.

In view of the number and variety of stations visited, number of collections made at these stations, and total specimens examined the scope of this study should provide a good estimate of the relative abundance of the simuliid species present in central Alaska. Adult collections made during the same period and in the same areas are not yet identified. These will provide information as to the species that are attracted to man and most likely to be of principal concern as pests.

A comparison of the Fairbanks and Anchorage biology stations reveals a marked difference in number and identity of the species present in each area, as well as considerable difference in the relative abundance of species common to both.

Table 6 shows results of survey and other collecting activities covering the area lying around Knik Arm from Anchorage to Goose Bay on the opposite shore. It is presented as evidence that the populations studied at the Anchorage biology stations are representative of that region.

Table 5.--Collections from biology stations.

	Anchorage			Fairbanks		
	Stations	Collections	Total specimens	Stations	Collections	Total specimens
Cnephia borealis	5	48	747			
pallens				8	30	432
pallipes				1	8	18
New genus, sp. 1 & sp. 2				4	55	698
Prosimulium fulvum	4	47	398			
hirtipes	13	146	3,060	4	37	284
onychodactylum	11	120	1,009			
pleurale	1	1	3			
sp. 1 (=Z)	7	80	1,239	4	29	326
sp. 2 (=D)	7	133	3,227	3	10	48
sp. 3 (=H)	7	30	126			
Simulium arcticum	6	45	312			
aureum				4	39	444
corbis	5	31	559			
costatum	11	90	1,340			
decorum	3	48	1,310	4	29	155
latipes	7	44	251	9	59	1,033
perissum	7	87	2,521	5	37	870
venustum	8	119	3,174	5	44	597
vittatum	5	101	5,407			
sp. 1 (=M)	1	1	2			
sp. 2 (=W)				1	5	30
sp. 3 (=X)	1	2	3			
sp. 4 (=A)	2	5	9			

Table 6.--Survey collections from the vicinity of Knik Arm and from Naknek.

	Number of collections	Total number of specimens
Knik Arm		
Cnephia borealis	3	108
New genus, sp. 1 & 2	1	2
Prosimulium fulvum	2	35
hirtipes	55	1,763
onychodactylum	22	427
sp. 1 (=Z)	1	2
sp. 3 (=H)	1	1
Simulium arcticum	8	401
corbis	9	187
costatum	17	121
decorum	1	1
latipes	4	130
perissum	13	319
venustum	3	243
vittatum	3	55
sp. 3 (=X)	2	14
Genus and sp. 1 (=#)	3	21
Naknek		
Cnephia borealis	2	76
Simulium arcticum	3	130
costatum	2	7
vittatum	1	6

For a list of species collected in Alaska during 1948, see table 7, and add _Prosimulium pleurale_ Malloch, _Simulium_ sp. 1 (=M), & _S._ sp. 4 (=).

Table 7.--General survey collections.

	Number of collections	Total number of specimens
Cnephia borealis (Malloch) (not Zett.)	26	270
pallens Twinn	20	202
pallipes Twinn, complex	61	802
New genus, sp. 1 and sp. 2	73	611
Prosimulium fulvum (Coq.)	1	12
hirtipes (Fries)	111	1,089
onychodactylum D. & S.	65	585
sp. 1 (=Z)	69	1,125
sp. 2 (=D)	134	3,266
sp. 3 (=H)	14	2,121
sp. 4 (=IV)	7	39
sp. 5 (=VI)	7	58
sp. 6 (=VIII)	5	48
sp. 7 (=IX)	2	30
sp. 8 (=X)	3	41
sp. 9 (=XI)	15	112
Simulium arcticum D. & S.	37	526
aureum Fries	17	161
corbis Twinn	22	244
costatum Fries	2	27
decorum Walk.	19	230
latipes Fries	80	773
perissum D. & S.	104	1,532
venustum Say	50	907
vittatum Zett.	17	686
sp. 2 (=W)	8	57
sp. 3 (=X)	13	270
sp. 5 (=V)	1	12
Genus and sp. 1 (=#)	3	48

Based on data from the foregoing tables, the following species were the most abundant in the Anchorage area, the order being determined by three factors, namely, number of stations at which a species was found, the total number of times a species was collected, and finally, the total number of specimens taken.

1. Simulium venustum
2. Simulium vittatum
3. Prosimulium hirtipes
4. Prosimulium onychodactylum
5. Prosimulium sp. 2 (=D)
6. Simulium costatum
7. Simulium perissum
8. Prosimulium sp. 1 (=Z)

In the Fairbanks area the following species were the most abundant:

1. Simulium latipes
2. Simulium perissum
3. Simulium venustum
4. Simulium aureum
5. Cnephia pallens
6. Prosimulium hirtipes

Further analysis of survey data will provide much additional information concerning geographic distribution. To a great extent distribution appears to be determined by the type of stream which is predominant in a given area. Thus, Simulium venustum is usually the most abundant species in areas where streams draining shallow lakes are common, while in areas where most streams are of the swift, cold, mountain type, Prosimulium hirtipes is far more common.

From a preliminary analysis of the data several of the Simulium species appear to have three generations at Anchorage but only two at Fairbanks. There is no evidence that any of the Prosimulium have more than one generation in either area. There is a well-defined succession of species among the Prosimulium. A single stream location often produces three or four species, each of which matures and emerges at different times.

Punkies (Heleidae)

R. I. Sailer, E. P. Marks, J. D. Gregson, and B. L. Morris

Five species of punkies, all belonging to the genus Culicoides, were collected during 1948 and determined by Dr. Alan Stone of the Bureau of Entomology and Plant Quarantine. Two specimens could not be recognized as belonging to a named species. Information concerning dates of collection and the distribution of the four remaining species is given below.

Culicoides biguttatus (Coquillett).--This species was collected at the following three localities: Mile 1247.6, Alcan Highway (Gardner Creek), July 14 (48); mile 70, Steese Highway, July 17 (2); and Eklutna Flats, Eklutna, August 12 (1).

Culicoides obsoletus (Meigen).--During 1947 this species was reported as one of the most widespread and annoying. During 1948 only 34 specimens were collected from five localities. These were as follows: Mile 70, Big Timber to Nabesna Road, July 29 (1); mile 65.9, Richardson Highway, July 26 (20); mile 97.8, Richardson Highway, July 27 (3); mile 137.5, Richardson Highway, September 8 (1); and mile 162.7, Richardson Highway, September 7 (9).

Culicoides tristriatulus Hoffman.--During 1947 this important species was reported as restricted to the coastal region; however, during 1948 it was collected at four localities situated between the Chugach and the Alaska ranges. These localities were mile 70, Big Timber to Nabesna Road, August 24 (2); mile 188.7, Richardson Highway, September 7 (1); mile 162.7, Richardson Highway, September 7 (8); and mile 137.5, Glenn Highway, September 8 (19).

Twenty-eight adults were reared from pupae, and one larva was collected at Fish Creek Flats near Anchorage (July 26-29).

A large population was present on the Valdez tidal flats as early as June 18. During the first half of July, dock workers were compelled to wear head nets and gloves during the early morning and in the evening when flight activity was greatest. Residents of the city seldom attempted to work in their yards and gardens during these hours, and a small swarm of the punkies would accompany anyone walking along the street during the evening. While the

punkie population was most abundant on the tidal flats adjacent to the city, observations made July 7 between the hours of 1905 and 2105 show that *tristriatulus* could be found up to 7 miles northeast of the city. However, the number of individuals present diminished very rapidly beyond 2 1/2 miles. A few adults were present on the tidal flats west of Valdez as late as August 25.

Some observations on the biology of this species were made at Valdez and at Anchorage. Results of these observations are reported under "Notes on the Biology of *Culicoides tristriatulus*."

Culicoides yukonensis Hoffman.--This was found to be the predominant species throughout central Alaska, 316 specimens being collected from the following 21 localities: Mile 25.7, Big Timber to Nabesna Road, July 18 (2); Desper Creek, mile 1225 Alcan Highway, July 14 (1); Gardner Creek, mile 1247.6 Alcan Highway, July 14 (35); Copper Center, July 17 (11); mile 162.7, Richardson Highway, July 24 (5); near the University of Alaska, Fairbanks, August 1 (14); Eklutna Flats, Eklutna, August 8 (8), August 12 (22), August 17 (14), September 13 (2); Eagle River Flats, Anchorage, August 16 (36); Otter Creek, Anchorage, August 21 (5); mile 70, Big Timber to Nabesna Road, August 29 (1); mile 91, August 28 (1); Richardson Highway, mile 65.9, August 26 (13); mile 97.8, August 27 (27); mile 81, August 27 (1); mile 286, September 1 (1); mile 326.7, September 1 (103); mile 162.7, September 7 (1); mile 204.2, September 7 (1); Berry Creek, mile 1377.5, Alcan Highway, August 31 (6); Steese Highway, mile 61, September 3 (5); and mile 140.4, September 5 (1).

Notes on the Biology of *Culicoides tristriatulus*

Rearing Observations.--Two attempts were made to locate the breeding sites of *Culicoides tristriatulus*. The first of these was undertaken at Valdez on July 8, and the second at Anchorage on July 26. Neither effort met with notable success, probably because both studies were undertaken too late in the season.

On July 8 a transect was made across the tidal flats about one-half mile west of Valdez. Samples of muck and vegetable debris were taken at 60-foot intervals along a line running from the road to the base of the mountain 300 yards to the north. Five additional samples were taken around fresh-water pools near the beach area about 1 1/2 miles west of Valdez. All samples were placed in glass jars and flooded with tap water. These were allowed to stand for 48 hours. Samples from near the base of the mountains and out as far as 40 yards on the flats produced heleid larvae in many stages and a few pupae. All the pupae were obtained between 60 and 120 feet from the base of the mountains. The mature larvae and the pupae were placed in rearing tubes. Three of the larvae were reared to adults and proved to be *Bezzia*. Adults emerged from seven pupae, four of which were *Dasyhelea* sp. and the remaining three were male *Culicoides tristriatulus*. One pupa which had been dipped from the surface of a shallow pool at the base of the mountain also emerged and proved to be *C. tristriatulus*.

Additional samples were taken on July 9 and 10 from the same area and heleid larvae and pupae were present in most of them; however, all specimens reared proved to be either Bezzia sp. or Dasyhelea sp.

Eight muck samples were taken at a lake 3 miles northeast of Valdez on July 11. One of these yielded a number of heleid larvae but of those reared none were Culicoides.

Emergence traps were placed over some promising spots on the tidal flat near the base of the mountain. After 5 days these had captured many small flies but no Culicoides.

The second attempt to find and rear Culicoides larvae and pupae was undertaken on July 26. On this date heleid type pupae were observed floating on the surface of a 1-inch deep pool containing Carex and Scirpus, located on Fish Creek Flats a short distance southwest of Anchorage. Sixteen pupae were collected and placed in rearing tubes. The first adult emerged the same day and the last on July 30. Of the 14 adult C. tristriatulus to emerge all but 1 were females. The two remaining specimens were Dasyhelea.

On July 27 seven muck samples were taken at this same pool, and all samples contained heleid larvae and pupae. Seven apparently mature larvae and 15 pupae were removed for rearing. Two of the larvae pupated and one that emerged was C. tristriatulus. Eleven of the pupae also produced adult C. tristriatulus. The remainder were Dasyhelea and Bezzia.

On July 29, 13 muck samples were taken along a line running the length of the flats. One sample taken 200 yards away from the pool at which the July 26 and 27 collections were made was found to contain numerous small heleid larvae. The pool from which this sample was taken was very similar to the first. All other samples were negative. Three C. tristriatulus emerged from pupae collected on this date at the original pool.

Additional samples were taken from the original pool on August 2 and 9. Very small heleid larvae were numerous in most samples, but no additional mature larvae or pupae were found. Samples taken August 16 from a Triglochin-Scirpus marsh on Eagle River Flats located north of Anchorage also contained large numbers of very small heleid larvae.

Observations Concerning Adults.--An extensive study of the effect of weather on the flight activity of C. tristriatulus was undertaken at Valdez between July 2 and 17. This study was primarily concerned with flight activity as reflected by the landing rate, and results are reported in the section on climatic studies. Some additional observations on adult behavior were made and are reported here.

The first of these concern male swarms of C. tristriatulus, which were seen about 1900 on July 2. The party had just arrived at Valdez and equipment for detailed weather observations had not been unpacked. Since numerous swarms were seen, it was assumed that there would be frequent subsequent opportunities for detailed study. This did not prove to be the case for no additional swarms were seen, although the area was under close observation through July 17.

The swarms observed on July 2 were made up of a few dozen to several hundred individuals. They hovered at an elevation of about 8 feet, and their location remained unchanged during an observation period of about 5 minutes. All specimens captured by sweeping through the swarms with a collecting net were males. About six swarms were seen, all being located on the tidal flats west of Valdez in the area crossed by the road to Mineral Creek. The weather was fair, sun low in the sky, temperature about 60° F., and wind velocity less than 0.5 mile per hour.

The second series of observations was on the hiding place or shelter sought by the adult Culicoides during times when conditions are not favorable for flight. Any attempt at adult control makes the location and accessibility of the punkies during their periods of inactivity a matter of considerable importance.

Extensive sweeping of the vegetation on the tidal flats, as well as at the edge of the flats, gave meager results. On one occasion several punkies were taken by sweeping 6 to 8 inches above the ground through the scattered vegetation of the flats, about 600 yards from the edge of the woods. These specimens were taken at 1900 on July 14, just before a flight began. Whether these adults were flying or resting was not determined.

On July 15 a line of 11 men, spaced at 20-yard intervals, was formed running from the edge of the woods across the flats to the water. This line was formed as the wind velocity dropped before an expected punkie flight. The first landings were reported about 200 yards from the edge of the woods. This test was repeated once during each of the two following days. On both days the line was formed before any punkies appeared. On July 16 the first adults were seen flying in the low vegetation about 40 yards from the edge of the woods. A few seconds later landings were reported at this point and subsequent landings followed progressively in both directions. On July 17 the first landings were reported simultaneously at the edge of the woods and at 40 yards out on the flats.

During the line test on July 16, one of the men reported seeing an adult crawl out of the moss on the ground and fly away. Pulling the moss apart and digging among the grass roots produced two female punkies. These were about 1 inch below the surface of the moss. A third specimen was found among grass roots beneath a log. At another place several adults were found when a rotten log was rolled over. These specimens were crawling about on the moist under-surface of the log. Others were seen to land on the log and crawl quickly into cracks and holes. The latter did not reappear. These observations were made during a period of intense flight activity. On July 17 punkies were again found under logs and in grass roots. They were seen at 0500 when large numbers were in flight and at 0800 when none were flying.

These observations suggest that punkies find shelter in almost any dark, moist retreat that is available in the area where they may be at the end of favorable flight conditions. The fact that specimens were found among tangled grass roots as much as 1 inch below the surface of the ground should increase greatly the importance of timing the application of adulticides to coincide with periods of maximum flight activity.

Horse Flies and Deer Flies (Family Tabanidae)

R. I. Sailer, S. Lienk, K. M. Sommerman, and M. Ridenour

No intensive study of the Tabanidae was undertaken during the 1948 season, but a considerable number of adults were collected incidentally throughout the central Alaskan area. These have been identified by Dr. Alan Stone, Bureau of Entomology and Plant Quarantine, and are listed below with locality data.

Tabanids were seldom encountered in large numbers and were never sufficiently annoying to be of pest significance. Tabanus septentrionalis was present in large numbers on the tidal flats near Valdez. This area was under observation from July 4 through July 16. Throughout this period they were numerous at times when the sun was bright and the temperature at least 70° F. Wind speeds of 5 m.p.h. did not seem to affect them adversely.

The species collected were as follows:

Chrysops excitans Walk.--Five miles southwest of Anchorage, June 21 (1); 36.3 miles northeast of Fairbanks, June 24 (1); Birch Creek, 149 miles northeast of Fairbanks, June 25 (2); Circle City, 14 miles southwest, June 25 (2).

Chrysops mitis O. S.--Fairbanks, near University of Alaska, July 1 (1), July 7 (2).

Chrysops nigripes Zett.--Eklutna, June 23 (1), June 30 (6), July 14 (1); Anchorage, Eagle River Flats, July 13 (2); Anchorage, 20 miles northeast, July 13 (1); and Glenn Highway, milepost 126, July 17 (1).

Chrysozona americana (O.S.).--Richardson Highway, milepost 355.7, July 12 (1).

Tabanus affinis Kirby.--Birch Hill, Fairbanks, June 15 (1); Bear Lake, 23 miles northeast of Anchorage, June 17 (1); Circle City, June 25 (1); Ladd Field, Fairbanks, June 25 (1); 36 miles northeast of Anchorage, June 30 (1); Birch Hill, Fairbanks, July 4 (1), July 14 (1); 10 miles southeast of Fairbanks, July 5 (1); 7 miles southeast of Fairbanks, July 5 (1); 4 miles west of the University of Alaska, Fairbanks, July 7 (1).

Tabanus astutus O.S.--Milepost 178.7, Glenn Highway, July 25 (2).

Tabanus epistates O.S.--Circle City, June 25 (1); 4.4 miles southwest of Circle City, June 25 (2); 4 miles west of the University of Alaska, Fairbanks, July 1 (4), July 7 (2); Birch Hill, Fairbanks, July 4 (3); 5 miles northwest of Fairbanks, July 5 (1).

Tabanus gracilipalpis Hine.--4.4 miles southwest of Circle City, June 25 (4); 10 miles southeast of Fairbanks, June 25 (1); Birch Hill, Fairbanks, July 4(2).

Tabanus illotus O.S.--Fairbanks, June 21 (5); Birch Hill, Fairbanks, July 4 (1).

Tabanus liorhinus Phil.--Milepost 178.7, Glenn Highway, July 25 (1).

Tabanus metabolus McD.--Ft. Richardson, June 15 (1); Eklutna Flats, Eklutna, June 9 (1); near University of Alaska, Fairbanks, June 12 (1); 14 miles southeast of Fairbanks, June 14 (1); Birch Hill, Fairbanks, June 15 (2), June 16 (1); Ladd Field, Fairbanks, June 18 (3); and Fairbanks, June 20 (1).

Tabanus septentrionalis Lw.--Richardson Monument, near 207 milepost, Richardson Highway, June 7 (24); 3 miles northeast of Valdez, June 11 (1); Ft. Richardson, July 1 (1); Fish Creek Flats, Anchorage, July 4 (1); Eagle River Flats, Anchorage, July 13 (13); Valdez, July 15 (7); 1 mile west of Valdez, July 16 (37); Valdez, July 17 (8); Anchorage, August 18 (5); 35 miles northeast of Anchorage, July 22 (1); and milepost 178.7, Glenn Highway, July 25 (8).

Tabanus sexfasciatus Hine.--4.4 miles southwest of Circle City, June 25 (1); near University of Alaska, Fairbanks, July 7 (1), July 14 (1).

Tabanus tetricus hirtulus Bigot.--Ten miles southeast of Fairbanks, June 25 (10); and milepost 126, Glenn Highway, July 25 (1).

Tabanus trepidus McD.--Birch Creek, 149 miles northeast of Fairbanks, June 25 (1); and Circle City, June 25 (1).

Snipe Flies (Rhagionidae)

R. I. Sailer and E. P. Marks

The snipe fly, Symphoromyia atripes Bigot, was found in the vicinity of Valdez. The species was frequently encountered on the glacial till plain behind the city. No specimens were seen in the city or on the adjacent tidal flats. They were generally observed in open areas between clumps of higher vegetation and acted very much like horse flies. They were most active when the sun was bright, wind velocity below 3 m.p.h., and the temperature around 70° F. Under favorable conditions as many as three or four specimens could be seen at a given time. In general, they were more aggressive than any of the horse flies encountered in Alaska during 1948.

MOSQUITO LARVICIDE TESTS

C. M. Gjullin, F. S. Blanton, B. V. Travis,
Nelson Smith, W. C. Frohne, C. N. Husman,
and C. S. Wilson, with assistance from the
entire group

The relative effectiveness of several insecticides for the control of mosquito larvae was determined both by prehatching and conventional larvicidal treatments. The test materials were applied with hand and with airplane equipment.

Prehatching Plots

One of the more recent approaches toward the control of marsh-breeding mosquitoes has been the application of insecticides to breeding areas prior to the hatching of eggs. The unusual stability of the new insecticides permits the application of treatments several weeks to months in advance of the mosquito breeding season. This method, now known as the preflooding or prehatching treatment, may prove a useful adjunct to other control measures and was given considerable attention in Alaska.

Materials and Methods

A total of 201 one-fourth and one-half acre plots were treated with rotary hand dusters and 3-gallon cylindrical pressure sprayers. Forty 5- to 10-acre plots were treated with either an L-5 or a UC-64 (Norseman) airplane.

The plots treated with hand equipment were in the vicinity of Anchorage, Gulkana, Tok, Tanacross, and Paxton, Alaska. Four or five replications were made of each treatment, one in each of several different mosquito-breeding environments--natural depressions and old roadways where sedge (Carex) was the predominant vegetation, and bogs with plant associations of Myrica (M. gale)-heath-Sphagnum, Sphagnum-heath, and Sphagnum-sedge-heath. The plots treated by airplane were in the following plant associations: deep grassy (Calamagrostis canadensis) depressions, Sphagnum-heath, Sphagnum-Myrica-birch (Betula nana), and Sphagnum-heath-sedge. These test areas were hummocky with accumulations of water between the hummocks, and all were known mosquito producers.

Half the plots were sprayed in August 1947. At this season there was little or no water in bogs having sedge or grass as the predominant vegetation, whereas in the other environments most of the depressions between the hummocks were filled with water. The remainder of the plots of each type were treated in March and April 1948, when the snow was 3 to 30 inches deep.

In the plots treated by hand DDT was applied in emulsions, fuel-oil solutions, dusts, and wettable powders. Chlordane, toxaphene, methoxychlor, TDE, and parathion were applied in fuel-oil solutions. Benzene hexachloride (12 percent gamma) was applied both in fuel-oil solutions and in 50-percent wettable powders. To each 5 gallons of fuel oil 1 quart of cyclohexanone was added to insure stable solutions during cool weather, and also, in the spring,

1 pint of alcohol to prevent moisture in the cans from freezing and stopping the spray nozzles. The dusts were diluted with pyrophyllite. All liquids were applied at the rate of 2.5 gallons per acre. The dusts were applied at 5 pounds per acre except for benzene hexachloride, which was applied at the rate of 8.4 pounds of dust per acre.

The airplane plots were treated with a 20-percent DDT concentrate diluted with fuel oil to obtain different dosages. From 2 to 8 quarts of spray per acre were applied in the fall and from 1 to 2 pints in the spring. Red dye was added to the sprays, and white cards were placed at 25-foot intervals across the plots to determine whether the spray was well distributed.

All plots were dipped from 2 to 6 times to determine the effect of the various treatments. In most tests from 30 to 60 dips per plot were made at each observation in the hand-treated plots and from 30 to 100 in the airplane plots. A total of 22,823 dips were made in the hand-treated plots, and 13,981 in the plots treated by airplane.

Although the number of larvae taken during the preliminary observations is reported, the percent control is based on the final observation and includes both larvae and pupae.

Results

Hand-treated Plots.--The data for the hand-treated plots, as summarized in table 8, are averages for all plots given the same treatment. Complete control was obtained only with DDT applied at the rate of 2 pounds per acre as an emulsion. A 90 percent or higher control was shown in plots treated with DDT in the fall at the following rates per acre: 2 pounds in fuel-oil solution, emulsion, and wettable powder; 0.5 pound in fuel oil and wettable powder; and 0.1 pound in an emulsion. Of the spring treatments, only the 0.1 pound dosage of DDT in fuel oil and the 0.5-pound dosage of TDE gave more than 90 percent control. The following applications gave 70 to 89 percent control: Fall applications of DDT at 1 and 0.1 pound in fuel oil, 1 and 0.5 pound in emulsions, 2 pounds in dust, and of benzene hexachloride wettable powder at 0.5 pound of the gamma isomer; spring applications of 0.5 pound of DDT in fuel oil and in emulsion. All other treatments gave less than 70 percent control. Parathion and methoxychlor were ineffective as prehatching treatments.

Table 8.--Effectiveness of prehatching treatments when applied with hand equipment for the control of *Aedes* mosquitoes. DDT applied in various formulations; all other materials, except benzene hexachloride wettable powder, applied as fuel-oil solutions.

Insecticide	Dosage (pounds per acre)	Season applied	Average number of immature forms per dip: Preliminary observations 1/	Average number of immature forms per dip: Final observations	Percent control
DDT		Fuel-oil Solution			
	2	Fall	0.06 (1/5)	0.05	98
	1	do.	.11 (2/5)	.35	83
	0.5	do.	.40	.08	96
		Spring	.64	.50	76
	.1	Fall	1.26	.54	74
		Spring	.23	.05	98
	.05	do.	1.29	.95	54
	.01	do.	1.00	1.81	12
		Emulsion			
	2	Fall	<.01 (1/4)	0	100
	1	do.	.47 (2/5)	.33	84
	.5	do.	.52	.47	77
		Spring	.22	.25	88
	.1	Fall	.09	.05	98
		Spring	.65	.94	54
		Dust			
	2	Fall	.44 (3/4)	.44	79
	1	do.	.42	.85	59
	.5	do.	1.20	1.80	13
		Spring	1.78	1.05	49
	.1	Fall	2.38	2.41	Increase
		Spring	3.33	4.78	do.
	.05	do.	6.16	4.26	do.
	.01	do.	2.30	1.35	34
		Wettable Powder			
	2	Fall	.13 (2/4)	.05	98
	1	do.	.21	1.79	13
	.5	do.	.04	.19	91
		Spring	.11	.90	56
	.1	Fall	.12	.89	57
		Spring	.63	7.30	Increase

Table 8.--(Cont'd.)

Insecticide	Dosage (pounds per acre)	Season applied	Average number of immature forms per dip: Preliminary observations 1/	Average number of immature forms per dip: Final observations	Percent control
Parathion	.1	Spring	3.18	10.89	Increase
	.05	do.	4.18	2.33	do.
	.01	do.	3.28	3.72	do.
TDE	.5	do.	<.01	.11	95
	.1	do.	1.85	3.07	Increase
Methoxychlor	.5	do.	1.24	3.43	do.
	.1	do.	1.77	3.82	do.
Chlordane	1.0	Fall	.72	.71	66
Toxaphene	1.0	do.	1.05	1.11	46
Benzene hexachloride:					
12% gamma	1.0	do.	.92	1.78	14
6% gamma wettable powder	2.5	do.	.03	.23	89
Check (untreated)	--	--	2.31	2.06	--

1/ All plots showed breeding except as indicated--e.g., (1/5) indicates that 1 out of 5 plots was breeding.

It was observed during the dipping that newly hatched larvae were being killed by some of the treatments. This observation is confirmed by the low counts in the preliminary observations of plots in which the treatments were effective. During the early observations it was common to find only first-instar larvae in treated plots, whereas in untreated plots other instars were present.

There was little evidence of a delayed kill. Dead larvae were rarely seen in the treated plots. In 16 of the 39 treatments, the larval population was not significantly lower at the final observation than during the preliminary observations. In the remaining treatments the final observation showed higher populations.

In a number of plots receiving various DDT treatments no larvae were taken during the entire study period. The effectiveness of treatments in these plots was confirmed by the death of larvae that were transferred to pools in these plots. Conversely, introduced larvae survived in plots where the insecticides appeared noneffective.

The degree of variation in populations in these studies is illustrated in table 9, which gives data for the moss-heath plots treated with DDT-fuel-oil solutions. All the variations may not be due to the chemical, as similar variations are noted in the check plots. It is evident, however, that even the 0.01-pound dosage affected the larval population, as the average count at the final observation was never higher than the highest count during the preliminary observations.

Table 9.--Variation in numbers of larvae per dip at different observations in moss-heath plots treated by hand with DDT in fuel-oil solution.

Dosage (pounds per acre)	Season of application	April 12	April 21	April 27	May 4	May 10	June 1
2	Fall	0	0.60	0	0.01	0.07	0.25
1	do.	.18	.57	.03	.02	0	.02
0.5	do.	0	.90	.52	.18	2.67	.22
	Spring	0	1.50	3.14	.56	.73	1.39
.1	Fall	.02	1.87	.48	.51	.23	.22
	Spring	0	.23	1.57	.20	.06	.06
.05	do.	0	1.90	1.76	.85	1.17	.38
.01	do.	.05	6.13	1.50	.22	.17	1.04
Check (untreated)	--	.05	5.10	4.67	1.62	3.00	3.48

In table 10 the data from all final observations on comparable dosages of DDT are averaged to show the effect of different environments, formulations, and seasons of application. The fall treatments were least effective in the moss-heath association and most effective in the sedge drpesssions, road tracks and moss-heath-sedge associations showing intermediate effectiveness. The spring treatments were least effective in the moss-heath association and most effective in the moss-heath-sedge association, the sedge depressions and road tracks showing intermediate effectiveness. In the spring fuel-oil solutions and emulsions were more effective than dusts and wettable powders. In the fall the dust was the least effective, but there was little difference between the other formulations. The variation between treatments within each association was so great that the average per dip for the fall treatments was not significantly lower than for the spring treatments.

Table 10.--Influence of breeding environment and season of application on effectiveness of DDT treatments applied by hand, as shown by average numbers of larvae per dip at final observation.

Dosage of DDT (pounds per acre)	Formulation	Sedge depressions	Road tracks	Moss-heath	Moss-heath-sedge	Average all environments
		Fall Applications				
0.5 and 0.1	Fuel oil	0.28	0.30	0.22	0.45	0.31
	Emulsion	0	.97	.09	.04	.28
	Dust	.51	1.62	4.24	2.06	2.11
	Wettable powder	0	0	.80	.37	.29
	Average	.20	.72	1.34	.73	.75
2 and 1	Fuel oil	0	0	.89	.12	.25
	Emulsion	.01	0	0	.66	.17
	Dust	.05	0	2.06	.50	.65
	Wettable powder	0	.08	3.33	.15	.89
	Average	.02	.02	1.57	.36	.49
		Spring Applications				
0.5 and 0.1	Fuel oil	.40	.01	.73	<.01	.29
	Emulsion	2.67	.02	1.04	0	.93
	Dust	.03	5.02	5.19	1.15	2.84
	Wettable powder	3.24	.01	6.95	.57	2.69
	Average	1.58	1.26	3.47	.43	1.69
Check (untreated)		.93	2.77	3.48	1.60	1.90

Thirty-nine of the hand-treated plots were abandoned and the data omitted in this summary, as they were in a floodwater drainage area.

Plots Treated by Airplane.--The results from plots treated with airplane equipment are presented in table 11. From 88 to 96 percent control was obtained with dosages of 0.5, 1, and 2 pounds of DDT per acre, and from 22 to 81 percent with 0.2 and 0.1 pound per acre. The average number of larvae per dip was higher at the final observation than in the preliminary count in all plots except those treated in the spring with 0.1 pound of DDT per acre. No significant difference could be noted between spring and fall treatments of 0.1 pound or between the 1-pint and 1-quart applications.

Table 11.--Effectiveness of DDT sprays as a mosquito-prehatching treatment when applied by airplane in different dosages and seasons.

Dosage per acre: DDT (pounds)	Dosage per acre: Solution	Season of treatment	Average number of immature forms per dip: Preliminary observations 1/	Average number of immature forms per dip: Final observations	Percent control
2	8 qt.	Fall	0.11 (4/5)	0.51	88
1	4 qt.	do.	.06 (3/5)	.15	96
0.5	2 qt.	do.	.16 (4/5)	.48	88
.2	2 qt.	Spring	.45	.74	56
	1 pt.	do.	.19	.78	81
.1	1 qt.	Fall	.60	.99	76
		Spring	1.64	1.32	22
	1 pt.	do.	.15	.49	29
Checks (untreated)					
Fall		--	--	4.2	
Spring		--	--	1.7	

1/ All plots showed breeding except as indicated--e.g., (4/5) indicates that 4 out of 5 plots were breeding.

In table 12 all final observations on comparable dosages are averaged to show the effect of different environments on the effectiveness of DDT as a prehatching treatment. Few or no larvae developed in plots that were located in grass depressions or moss-heath-birch, moss-heath, and moss-heath-sedge associations. The treatments were least effective in marshes containing _Myrica gale_, which occur commonly in seepage areas next to the hills and moraines on coastal flats and river flood plains. Conventional larvicide treatments likewise were least effective in this environment.

Table 12.--Influence of breeding environment, season of application, and dosage on the effectiveness of DDT treatments applied by airplane, as shown by average numbers of larvae per dip at the final observation.

Breeding environment	Fall treatments: 2 pounds	Fall treatments: 1 pound	Fall treatments: 0.5 pound	Spring treatments: 0.2 pound	Spring treatments: 0.1 pound	Average
Grass depressions	0	0	0	--	--	0
Moss-heath	.03	0	0	.02	.04	.02
Moss-heath-birch	0	0	0	--	--	0
Moss-heath-sedge	--	--	--	.22	.42	.32
Myrica-Calamagrostis	0	.73	1.20	--	--	.64
Myrica-moss-heath	2.50	0	1.22	1.19	2.62	1.51
Myrica-moss-heath-birch	--	--	--	1.62	.54	1.08

Five of the plots treated with airplane equipment were inadvertently placed in an area that failed to hold water this season, although the marsh produced many mosquitoes in 1947. These plots were abandoned and the data are not included in this summary.

Discussion

The results of these prehatching treatments are difficult to interpret. The newly hatched larvae are killed so rapidly that it is not possible to make accurate estimates of control on a basis of larval reduction within the treated plots. Moreover, the larval populations are so variable that control calculated on the basis of populations in untreated areas may not reflect the true effectiveness of the treatments. Hatching occurred over a period of several weeks in both treated and untreated areas. During this period larvae of all sizes were taken in the untreated areas, whereas in the treated plots only newly hatched larvae were present. This difference, as well as the difference in total populations, indicates that the larvae were being killed in the treated area shortly after hatching.

The data indicated that prehatching treatments could be relied upon to give satisfactory control except in Myrica marshes. The reasons for the lack of effectiveness in this type of breeding area were not determined. However, the fact that treatments both in the fall, when Myrica marshes were relatively dry, and in the spring, when they were covered with snow, were ineffective suggests that soil or water conditions in such areas may inactivate the DDT.

The practicability of prehatching treatments as a routine control method in much of this region is questionable. Further studies, however, may show this method to have a wider application than the present data indicate. Owing to the long flight range of Alaskan Aedes and the many square miles of breeding area adjacent to inhabited communities, it is likely that better mosquito control could be obtained with the same total amount of material applied by other methods. For example, at least 0.5 pound of DDT per acre was necessary in the prehatching treatment, whereas 0.1 pound was sufficient for conventional larvicidal treatments or for control of adults.

The prehatching method of control may be practicable in localities where mosquitoes are produced on localized breeding areas, such as exist in much of the Anchorage area. Many of these locations have little run-off, so that heavy dosages can be applied without danger to wildlife. It will be especially important to continue observations on the areas where the amount of DDT applied during the year totals 0.5 pound or more per acre. It is not unreasonable to expect a general reduction in mosquito breeding in such areas.

Larvicide Plots

During the 1947 season, a large series of plots was treated by hand to determine the most practical dosages of DDT and to evaluate some of the other insecticides. A number of plots were also treated by hand in 1948 to determine their effectiveness under Alaskan conditions. Additional plots were treated by airplane to confirm the hand-plot results, and one large-scale practical application was made.

Hand-Treated Plots

Tests with DDT, TDE, methoxychlor, and parathion oil solutions were made on 30 one-half acre plots near Anchorage and Eklutna. The most common species of larvae were *Aedes punctor*, *A. communis*, and *A. impiger*. The larvae ranged from first to fourth instars, and third or fourth stages predominated in all tests. The sprays were applied with a small hydraulic-type sprayer and with a Flit-gun.

The Anchorage area tests were made on mossy pools partially filled with grass. The results of the tests on these plots, table 13, indicated that TDE and methoxychlor were only slightly less toxic than DDT at 0.1 pound per acre. Freshly prepared oil solution of parathion at 0.025 pound per acre was indicated to be nearly four times as toxic as DDT. A parathion-fuel-oil solution, about 2 months old, showed no toxicity to mosquito larvae at 0.02 pound per acre.

Table 13.--Results of small-plot tests on *Aedes* larvae made in the vicinity of Anchorage and Eklutna, Alaska, May 1948.

Material	Dosage (pound/acre)	Number of tests	Percent mortality in 24 hours	Percent mortality in 48 hours
	Anchorage			
TDE, 2.5% in fuel oil	0.1	3	84	84
Methoxychlor, 2.5% in fuel oil	.1	3	79	82
Parathion, 0.25% in fuel oil	.025	3	59	66
DDT, 20% in fuel oil	.1	2	66	88
	.2	5	93	97
Velsicol AR-50[1/] 50%, fuel oil 50%	2 quarts	2	0	0
	Eklutna			
TDE, 2.5% in fuel oil	.1	4	55	68
DDT, 2.5% in fuel oil	.1	4	44	52
Methoxychlor, 2.5% in fuel oil	.1	4	44	48

1/ Chiefly mono- and dimethyl-naphthalenes.

In the Eklutna plots the larvae occurred in pools between shrub-covered tussocks on flat seepage areas. In these tests TDE, DDT, and methoxychlor were much less effective at 0.1 pound per acre than in the Anchorage area. These plots were similar with respect to drainage and vegetation to those in which 0.4 pound of DDT failed to give larval kills in 1947. Prehatching sprays applied to this type of breeding area have also been found less effective than on other types of areas. The reasons for the ineffectiveness of the insecticides under these conditions were not determined.

Plots Treated by Airplane

The majority of mosquito breeding places in Alaska are inaccessible to ground-spray equipment because of closely grown forest, boggy marshes, and lack of roads. Breeding places in the vicinity of Anchorage range from small pools to areas of 100 acres or more. In the Fairbanks region heavy breeding occurs over many square miles of lowlands which become partially or entirely flooded and results in huge adult populations. Under such conditions airplane treatments are the only feasible means of controlling either the larvae or adults.

Tests were made in the vicinity of Anchorage on 16 plots ranging from 4 to 25 acres in size to determine the relative effectiveness of 5-percent and 20-percent DDT sprays. Applications of 0.1 and 0.2 pound per acre were made with 5 percent of DDT in Diesel oil, and with a solution containing 20 percent of DDT, 40 percent of Velsicol AR-50, and 40 percent of fuel oil. Tests were also made with a 20-percent DDT solution containing 1 percent of Triton B-1956 emulsifier to increase the spread on water. Sprays were applied with an L-5 airplane, equipped with standard under-wing spray booms, from a height of 50 to 100 feet in 100-foot swaths.

One series of tests was made in mossy pools partially filled with grass, a second series in pools on a moss-heath bog, and a third series on areas containing both these types of breeding environments. Aedes communis, A. impiger, and A. punctor comprised about 90 percent of the larval population, with small numbers of A. excrucians and A. pionips in some plots. Larvae of all instars were present, but third and fourth stages predominated.

With applications of one-half pint of a 20-percent DDT solution per acre (0.1 pound of DDT per acre), the kills were 95 and 99 percent, respectively, in 24 and 48 hours, and with a quart of a 5-percent solution, 90 and 95 percent (table 14). Applications of 1 pint of 20 percent DDT solution per acre (0.2 pound of DDT per acre) gave 100 percent control in 24 hours, while 2 quarts of the 5-percent solution caused 89 and 91 percent mortality in 24 and 48 hours. The 20-percent DDT solution containing 1 percent emulsifier gave a kill of 86 percent in 24 hours and 93 percent in 48 hours, as compared with 95 and 99 percent kill for a similar solution without the spreader. The reasons for the reduced effectiveness of the solution with the emulsifier were not determined.

Winds ranging from 4 to 11 m.p.h. and temperature drops of 9° to 50° F. from the surface to the 50-foot level occurred during some of these tests but, contrary to expectations, such conditions caused no reduction in the effectiveness of treatments. (See Climatic Studies section.)

The effectiveness of 20-percent DDT, Velsicol AR-50, and fuel oil solution as a larvicide treatment was studied in two large-scale tests at Ladd Field near Fairbanks. An area approximately 5 by 6 miles, including Ladd Field, was sprayed in the two tests. The terrain in the area is low and flat. Most of it is covered with trees and brush, but a considerable portion is open. Approximately 50 percent of the area had been flooded, and most of the water contained large numbers of larvae, as well as some pupae. Aedes punctor, A. intrudens, and A. communis were the most common species. A. impiger, A. excrucians, and A. stimulans were also present in numbers.

Table 14.--Results of tests with DDT sprays applied with an L-5 airplane against *Aedes* larvae in the vicinity of Anchorage and Eklutna, Alaska, in May 1948.

Material	Dosage per acre: Pints of solution	Dosage per acre: Pounds of DDT	No. of tests	Percent mortality after 24 hours	Percent mortality after 48 hours
20% DDT, 40% Velsicol AR-50, and 40% fuel oil	0.5	0.1	4	95	99
	1	.2	3	100	100
20% DDT, 40% Velsicol AR-50, 39% fuel oil, and 1% B-1956	.5	.1	3	86	93
5% DDT in fuel oil	2	.1	3	90	95
	4	.2	3	89	91

Six square miles of this area were sprayed with 20-percent DDT, Velsicol AR-50, and Diesel oil solution at the rate of 0.1 pound of DDT (or 1/2 pint of solution) per acre, and the adjoining 24 square miles at the rate of 0.2 pound of DDT (or 1 pint of solution) per acre. The treatments were applied with a C-47 airplane equipped with under-wing spray booms. Applications were made from a height of 50 to 100 feet and at swath intervals of 800 feet.

The application of 0.1 pound of DDT per acre caused a mortality of 86 percent in 24 hours and 89 percent in 48 hours. Winds ranged from 7 to 13 m.p.h. during this application, but the lapse rate was negligible. The low kill was due largely to high larval survival in a small portion of the plot. This section of the plot could not be sprayed properly because hills prevented a low approach and because of a strong wind which carried the spray away before it reached the ground.

Applications of 0.2 pound of DDT per acre caused a mortality of 97 percent in 24 hours and 99 percent in 48 hours. The wind velocity during this test ranged from 1 to 6 miles per hour. A steep lapse rate prevailed while half of this area was being sprayed but apparently had no adverse effect on the results. Neither the 0.2 or 0.1 pound dosage of DDT appeared to be effective against pupae.

The highly effective larval control obtained in this 30-square-mile area provided only temporary relief from adult mosquitoes. Large numbers of adults migrated from surrounding untreated areas within 10 days, and it was necessary to respray the area for their control. It was therefore shown that an area much greater than 30 square miles would have to be treated in order to obtain protection for a longer period.

BLACK FLY LARVICIDE TESTS

C. M. Gjullin, D. A. Sleeper, C. N. Husman, and Austin J. Hicks

The studies during 1948 included a more careful comparison of several of the materials which had given promising results in tests for the control of black fly larvae last year. These comparisons were made with hand applications to small sections of streams. The major emphasis, however, was given to tests to determine the practicability of airplane applications of DDT for the control of black fly larvae.

Hand Applications

Comparative tests with DDT, TDE, methoxychlor, and parathion were made against black fly larvae in the End Fork of North Ship Creek near Anchorage. This stream contained a moderately large population of fourth instar Prosimulium onychodactylum D. & S. and small numbers of P. hirtipes (Fries).

The stream flow was measured before each test by means of a weir, and ranged from 3 to 4 cubic feet per second. The insecticides were dissolved in acetone and dripped into the stream at a constant rate to give a predetermined parts-per-million concentration for 8 minutes. Stream temperatures ranged from 41 to 43° F.

Observations were made on stream sections approximately 50 feet long. Pretreatment counts of the larvae on 10 rocks were made at the lower end of each stream section, and to avoid disturbance of the larvae they were counted through the bottom of an Erlenmeyer flask. The larvae were again counted after treatment to determine the effect of the insecticide. Counts made 6 hours after treatment were found to give the same percentage of detached larvae as those made at 24 hours.

Applications of DDT, TDE, and methoxychlor at the rate of 0.025 p.p.m. for 8 minutes (table 13) caused larval detachments of 97, 97, and 98 percent, respectively. The percentage of detachment for individual tests of this series ranged from 94.5 to 99.2 percent. Parathion at half this dosage was ineffective.

In another series of tests on fourth instar populations of Prosimulium hirtipes and P. onychodactylum on Saddle Fork of North Ship Creek near Anchorage, a treatment time of 6 minutes at 0.3 p.p.m. of DDT caused detachment of all larvae in four tests, while a treatment time of 5 minutes caused complete detachment in only two of four tests.

Table 13.--Toxicity to black fly larvae of acetone suspensions containing 1 percent of insecticide applied for 8 minutes.

Insecticide	Dosage (P.p.m.)	Number of tests	Percent larval detachment on rocks
DDT	0.025	3	97
TDE	.025	3	97
Methoxychlor	.025	3	98
Parathion	.0125	1	17
	.00625	1	22

Airplane Applications

During the summer of 1948 a number of experiments were conducted in which DDT-oil sprays were applied to streams in Alaska by airplane to determine the distances downstream such treatments would affect the black fly larvae. Airplane spray containing 20 percent of DDT, 40 percent of Velsicol AR-50, and 40 percent of fuel oil was applied to streams with an L-5 or a C-47 airplane. Both planes were equipped with wing-bar spray equipment. The L-5 plane was calibrated to deliver 0.2 pound of DDT per acre (1 pint of 20 percent solution) with a 100-foot swath, and the C-47, 0.1 pound (1/2 pint of 20 percent solution) with an 800-foot swath. The planes flew 50 to 100 feet above the water, and in all but one test the treatments were applied by spraying one or more swaths at right angles across the stream. When more than one swath was applied, each was across the same section of the stream. A 2,400-foot section of one stream was treated by spraying downstream for this distance.

Larval counts were made before and after spraying, on rocks, sticks, and trailing vegetation. Control in all tests was based on the distance downstream in which there was total elimination of larvae. In the tests on the Chatanika River, control was calculated by counts before and after treatment on 4 to 10 rocks at a number of locations below the treated section of the stream. These counts were made by direct observation through the bottom of an Erlenmeyer flask, held partly under water in order to avoid disturbing the larvae which were attached to rocks.

As shown in table 14 one 100-foot swath at a dosage of 0.2 pound of DDT per acre caused all black fly larvae to detach for 0.5 mile downstream. Four 100-foot swaths at this dosage caused complete detachment for 2 miles. With 0.1-pound dosages applied to 800- to 2,400-foot sections (one to four swaths with the C-47) of streams, complete control was obtained from 1 to 2 1/2 miles downstream. There appeared to be no close correlation between the length of the treated sector and the distance of 100 percent effectiveness. The percentage of partial detachment downstream in the Chatanika River, however, was increased by the heavier treatments. Counts of larvae on rocks before and after treatment gave the following percentages of detachment below the point of application: For the 800-foot treatment 92 percent at 3.5 miles; for the 1,600-foot application 81 percent at 4 miles, 70 percent at 5 miles, and 58 percent at 7.5 miles; for the 2,400-foot application 88 percent at 6 miles, and no reduction at 11 miles. No discernible differences in the resistance of the various species of black fly larvae were noted.

Table 14.--Distance that DDT-oil sprays were effective in causing complete detachment of black fly larvae in streams. Alaska, 1948.

Streams	Species	DDT (Pounds per acre)	Length of application (feet)	Larval detachment of 100 percent (miles)
Chester Creek	Prosimulium onychodactylum D.& S.	0.2	100	0.5
Wasilla Creek	Simulium arcticum Mall.	.2	400	2
		.1	800	2.5
		.1	800	2
Paul River	S. vittatum Zett.	.1	800	2.5
Fish Creek	S. venustum Say-vandalicum, D. & S. complex	.1	800	2
Chatanika River	S. arcticum Mall., S. corbis Twinn,	.1	800	1.5
	and S. venustum-vandalicum complex	.1	1,600	2
		.1	2,400	1
Naknek River	S. arcticum Mall., S. vittatum Zett.	.1	1,600	1.5

In connection with the routine spraying of one of the Army areas, a station for the study of black fly biology was inadvertently treated on June 13. The population of Similium venustum Say and S. vittatum Zett. larvae was completely eliminated from the stream and, although eggs and small larvae were observed at intervals after July 10, the larvae did not develop. The first larvae to remain and pupate were noted on August 10. It was not known whether residual DDT prevented development of the larvae or whether DDT continued to drain into the stream from the headwater bogs in sufficient quantity to kill the newly hatched larvae.

CONTROL OF ADULT MOSQUITOES

F. S. Blanton, C. N. Husman, B. V. Travis, G. L. Hutton,
N. Smith, C.S. Wilson, W. C. Frohne, K. H. Applewhite,
S. E. Lienk, E. F. Knipling, and L. W. Nielsen

Tests on the control of mosquito adults during the 1948 season in Alaska were conducted to determine the size of area necessary to treat in order to prevent infiltration in annoying numbers from the surrounding unsprayed areas, to obtain information on the number of times an area must be treated to protect a community from mosquitoes, and to establish the minimum effective dosage of DDT.

The Alaska Command and the Alaska Insect Project pooled supplies of DDT, planes, and personnel, and some of the military installations were used for the large-scale spray tests. Consequently, the Insect Project was able, in most cases, to combine research work with actual practical control activities for the local military installations. Large areas were sprayed at Ladd Field, near Fairbanks, Eielsen Field, 25 miles, and Big Delta about 100 miles away.

Materials and Methods

The plots were treated with a C-47 airplane equipped with a special spray apparatus designed by C. N. Husman and built by the Alaska Command. Standard 20-percent DDT airplane spray containing either 40 percent of Velsicol AR-50 and 40 percent of fuel oil; 28 percent of Velsicol AR-50 and 52 percent of fuel oil; or 15 percent of Velsicol AR-50 and 65 percent of fuel oil was used undiluted in all except the reduced dosage tests. Fuel oil was used as a diluent to obtain reduced dosages of 0.05 (10-percent DDT solution) and 0.025 (5-percent DDT solution) pound of DDT per acre. One-half pint of liquid per acre was applied except in two tests where 2 pints of 20-percent spray were used to give a dosage of 0.4 pound.

The sprays were applied at swath intervals of 800 feet, flown cross-wind. The flight lines were marked with flags or with smoke grenades, and in one instance with balloons, placed at one end or in the middle of plots. The pilots flew the swaths either by compass after orienting over the markers or by the use of maps on which the flight lines had been drawn previously. All sprays were applied between 1900 and 0300, as mosquito activity usually was greatest during this period. The wind was usually 0 to 8 m.p.h., although on a few occasions winds of 11 to 15 m.p.h. were encountered. Inversion conditions were ideal for the application of small-droplet sprays.

Mosquito populations were determined before and at intervals after spraying by landing-rate counts at a number of selected locations in the test plots. Counts were made of mosquitoes landing on the front of the trousers, waist to cuff, after standing quietly for 3 minutes at the check station. All counts were made as near the same time of day as possible. Frequently, different observers made the counts, and in a few cases the counts were made by two observers at the same station.

Results

Ladd Field Tests

The northern section of the area, Birch Hill, is a 6-square-mile block, bounded on the north by a line of hills about 200 feet high and on the south by the Chena River. Immediately adjacent on the south is the airfield. The southern section, Tanana, is a 24-square-mile block, bounded on the north by the Chena River and on the south by the Tanana River. The general terrain is flat and marshy. Some portions are densely wooded with birch and alder, some have a moderately dense growth of spruce and larch, and some only a low growth of shrubs, mostly Betula nana. A considerable part of the area is a moss-sedge bog.

The Birch Hill area was difficult to spray because the hills were dotted with beacons, towers, and power lines. Wind conditions were more unstable in this area than in the Tanana sections. The pilot was required to fly one corner of the area with the plane higher than normal and with a tail wind. Much of the spray drifted away from this area, resulting in a reduced dosage. This condition was particularly pronounced in the second application at Ladd Field.

The total area sprayed included the air field and was approximately 6 by 5 miles. Two tests were made on the control of adult mosquitoes, one the night of June 14 and the other the night of June 25. This area also had received a larvicidal treatment May 13, and subsequent to June 25 it received a routine spraying by the Area plane.

The data, table 15, show that an average of 98-percent reduction of mosquitoes was obtained by the spraying of June 14, and better than 80 percent control was indicated for at least 6 days. Mosquito populations began increasing near the outer borders shortly after spraying, but the main part of the post remained nearly free of annoyance for almost a week. At the time of the second application, June 25, the population was only about one-third of that present before the first spraying.

The second application was not as effective as the first in the Birch Hill section, probably because the wind increased from a slight breeze to approximately 15 m.p.h. during the spraying. The resulting control in this area was only 32 percent. The wind dropped to 5 m.p.h. during the spraying of the Tanana section, and 94-percent control was obtained, the same as in the first test. Since the Birch Hill section represented only one-fifth of the sprayed area, a weighted percentage would show 80-percent control over the whole area.

Table 15.--Adult mosquito reduction obtained at Ladd Field with 0.1 pound of DDT per acre applied with a C-47 airplane. Alaska, 1948.

Test section	Number of counting stations	Average landing rate before spraying	Percent reduction after (days)-- 1	2	4	6	7	8[1/]
		First Application, June 14						
Birch Hill (6 square miles)	23	32	98	94	92	94	88	91
Tanana (24 square miles)	13	10	94	91	78	95	44	76
		Second Application, June 25						
Birch Hill	23	8	32[2/]					
Tanana	11	13	94					

1/ Counts made in morning after an all-night rain.
2/ The wind in the Birch Hill section at the time of spraying was approximately 15 m.p.h., but dropped to 5 m.p.h. in the Tanana section during spraying.

Eielsen Field Tests

The treated area is bounded on one side by a long line of hills 200 to 300 feet high, and on the opposite side by the Tanana River. It was about 5 by 5 miles in size and included the airfield. The terrain is very flat and, in general, similar to that around Ladd Field, except that some areas have a heavier stand of spruce. Two test applications were made, one on the night of June 15 and the other on the night of June 24. Subsequently, the area received an additional routine spraying by the Area plane.

The data, table 16, showed that the first spraying gave a 95-percent reduction, and 91-percent control was indicated after 5 days. Adult infiltration occurred rapidly and by the seventh day the reduction was only 61 percent. The second treatment of Eielsen Field, on June 24, resulted in only 85-percent reduction of adult mosquitoes. Failure to achieve higher control in this operation may have been due to the use of old DDT solutions (20 percent of DDT, 15 percent of Velsicol AR-50, and 65 percent of fuel oil).

Table 16.—Adult mosquito reduction obtained at Eielsen Field with 0.1 pound of DDT per acre applied with a C-47 airplane. Alaska, 1948.

Number of counting stations	Average landing rate before spraying	Percent reduction after (days)— 1	2	5	6	7
		First Application, June 15				
31	60.7	95	94	91	78	61
		Second Application, June 24				
30	21.4	85				88 1/

1/ Counts were made in the morning after several days' rain.

Big Delta Airfield Tests

The treated area is bounded on one side by a high escarpment which leads to the Tanana River valley and on the opposite side by a wide river flood plain. It is about 2 miles square and includes the airfield. The terrain is moderately flat with little marsh land. Most of the area is covered with low shrubs, with fairly dense clumps of spruce and quaking aspen. Two test applications were made, one at the rate of 0.1 pound of DDT per acre on the night of June 16, and one at 0.4 pound per acre on June 23. Subsequently, an area of about 24 square miles, including the above, was resprayed by the Area plane.

Mosquito counts, table 17, showed 83-percent reduction 24 hours after spraying with the 0.1-pound dosage, but after 48 hours the reduction was only 72 percent. Seven days after the spraying mosquitoes were more numerous than before treatment.

Table 17.—Adult mosquito reductions obtained at Big Delta with DDT applied with a C-47 airplane. Alaska, 1948.

Number of counting stations	Average landing rate before spraying	Percent reduction after (hours)— 12	24	36	48	168
		First Application, June 16, 1948 - 0.1 pound per acre				
10	12.3		83		72	
		Second Application, June 24, 1948 - 0.4 pound per acre				
13	14.3	96	91	94	82	66

Results of the second spraying of Big Delta airfield with 0.4 pound per acre showed reductions of 96, 91, 94, and 83 percent after 12, 24, 26, and 48 hours, respectively. Seven days after treatment the reduction was only 66 percent.

Repeater Station, located a short distance from Big Delta, was also sprayed with 0.4 pound per acre. The percent reduction is tabulated below.

Number of counting stations	Average landing rate before spraying	Percent reduction (hours after spraying)—				
		12	24	36	48	168
14	25.5	93	93	95	88	60

Dosage Study Tests

Seven plots, each 3 square miles in area, were treated with DDT, three at a rate of 0.05 and four at 0.025 pound per acre. In addition, one plot of 1 square mile and another of 4 square miles were treated with 0.4 pound per acre. All of these plots were flat and covered with a moderately dense growth of spruce. The results of these tests and those of the large area tests are summarized in table 18, so that a comparison of effectiveness can be made between various dosages of DDT.

In the small-area tests a mean reduction of 39 percent resulted from the 0.025-pound dosage, 80 percent from the 0.05-pound dosage, and 92 percent from the 0.4-pound dosage. The 0.4-pound dosage showed reductions of 82 and 88 percent at 48 hours, and 66 and 60 percent at 7 days. In the seven large-area tests, a dosage of 0.1 pound per acre gave a mean reduction of 83 percent. By excluding the one test at Birch Hill, which was made under unfavorable conditions, the mean reduction for the 0.1-pound dosage would be 92 percent. Under favorable conditions, therefore, an application of 0.1 pound of DDT would seem adequate for practical control operations.

Table 18.--Adult mosquito reduction obtained in Alaska with various dosages of DDT applied at the rate of one-half pint of solution per acre.

Dosage of DDT (pounds per acre)	Plot area (square miles)	Average number of mosquitoes (landing rate) at the counting stations before spraying	Percent reduction 24 hours after spraying
0.025	3	29.5	60
	3	32.5	64
	3	25.0	17 1/
	3	10.5	14 1/
	Average	24.4	39
.05	3	19.8	85
	3	45.5	82
	3	24.7	73
	Average	30.0	80
.1	6	32	98
	24	10	94
	6	8	32 1/
	24	13	94
	25	60.7	95
	25	21.4	85
	4	12.3	83
	Average	22.5	83
.4 2/	4	14.5	91
	1	25.5	93
	Average	20	92

1/ Low kill due to excessive wind during spray operations.
2/ Two pints of 20-percent DDT applied per acre.

Infiltration Studies

An effort was made to determine the rate of infiltration of mosquitoes into a sprayed area from the surrounding unsprayed region. The Eielsen Field area, 5 miles square, was selected for these observations. Landing counts were made at 30 stations, 800 feet apart, in a line across the treated area before spraying, and on the first, second, fifth, sixth, and seventh days after spraying.

Data from these observations are given in table 19. It may be noted that mosquitoes were almost completely eliminated up to the fifth day within a radius of 1,600 feet of the center of the area, and the reduction in this portion was still fairly high (85 percent) on the seventh day. The remainder of the area showed an average reduction of only 60 percent on the seventh day. Most rapid infiltration occurred from the south side of the area.

From these observations it was evident that the local species of Aedes are capable of rapid and widespread dispersion so that the spraying of an area as large as 25 square miles would not ensure lengthy protection of a central point.

Table 19.--Mosquito infiltration into a large sprayed area from surrounding unsprayed area. Eielsen Field, Alaska, June 15, 1948.

Distance from center of ground area (feet)	Number of mosquitoes before spraying	Percent reduction after (days) 1	2	5	6	7
0	100	100	98	99	90	90
800	100	96	100	100	70	88
1,600	88	100	100	100	82	76
2,400	94	99	100	97	83	39
3,200	109	100	97	93	90	51
4,000	176	99	98	89	87	79
4,800	148	93	96	93	84	62
5,600	171	97	95	95	83	56
6,400	90	100	99	87	52	31
7,200	126	91	95	87	77	68
8,000	97	96	90	80	34	71
8,800	147	100	95	87	74	76
9,600	129	94	88	89	83	63
10,400	165	97	95	87	77	50
11,200	204	77	83	82	82	65

Discussion and Conclusions

One of the main objectives of the season was to determine how large an area must be treated to prevent reinfestation following a single treatment. The answer to this objective was not realized, but it was learned that a 2.5- to 3-mile radius is inadequate for the species of mosquitoes present in Alaska. A fair degree of relief from annoyance, however, was realized for from 5 to 7 days when areas of this size were treated. From the experience in 1948, it appears that four sprayings may be necessary to provide protection for a season. Even when DDT was applied at the rate of 0.4 pound per acre by air, a radius of 1 mile was provided protection for only 24 to 48 hours.

The dosage studies show that 0.1 pound of DDT per acre is an effective dosage and that little is to be gained with four times this rate of application.

AQUATIC BIOLOGY

D. A. Sleeper, C. M. Gjullin, K. H. Applewhite, Austin Hicks, and N. Smith

In 1947 a large number of tests were made in Alaska to determine the toxicity of several insecticides to several species of fish and to aquatic insects that are important as fish foods. In 1948 similar tests were made with DDT, TDE, methoxychlor, and parathion against arctic grayling, *Thymallus signifer* (Richardson), collected from a small stream near Nabesna, Alaska.

In these tests acetone solutions containing 1 percent of insecticide were added in sufficient amounts to 130 liters of stream water collected in a metal trough to give the concentration desired for each test. After the water and insecticide were well-mixed in the trough, 10 grayling, 4 to 7 inches in length, were exposed in the water for 15 minutes and then transferred to hardware-cloth wire cages anchored in the stream. The fish were observed for 24 hours to determine the effect of the chemicals.

As shown in table 20 the maximum safe dosage of DDT, with a water temperature of 50° F., was 60 p.p.m. At 75 p.p.m. of DDT, 20 percent of the fish were disabled and 10 percent died in 24 hours. Exposure to this concentration at a higher temperature (64°) resulted in 50-percent disability and 30-percent mortality. In this test the fish were transferred from 50° stream water to 64° water in the trough, and then returned to a cage in the stream, and it is possible that these sudden changes in temperature contributed to the higher kills.

TDE at 80 p.p.m. caused 30-percent disability but no mortality at water temperatures of 47° to 50° F. At a temperature of 64°, a concentration of 75 p.p.m. caused 40-percent disability, and 90 p.p.m. caused 100-percent disability during the 15-minute exposure period and 20-percent mortality in 24 hours. Methoxychlor at 35 p.p.m. caused 40-percent disability and 50-percent mortality; and at 30 p.p.m., 10-percent disability and no mortality. A concentration of 10 p.p.m. of parathion caused 10-percent disability and 45-percent mortality, and at 7 p.p.m. 10 percent became disabled but recovered completely in 24 hours.

Tests were made to determine the toxicity to grayling of oil solutions of 20-percent DDT and TDE applied on the surface of the water in troughs at the rate of 20 quarts per acre, or 8 pounds per acre of the toxicant. Fish were exposed in the DDT test for 3 hours, and during that time many of them darted to the surface to feed on insects. A total of about 20 insects out of 50 placed on the surface were eaten. The oil film was removed after 3 hours and the fish transferred to a cage in the stream. None became affected during the exposure or died within 24 hours. Similar results were obtained in a 2-hour exposure test with TDE.

Table 20.—Effect of larvicides on 4- to 7-inch grayling (10 fish per test, exposed for 15 minutes).

Foundation	Number of tests	Temperature (°F.)	Dosage (p.p.m.)	Percent helpless in 15 minutes	Percent dead in 24 hours
	DDT				
Acetone solution	1	52	35	0	0
	1	52	50	0	0
	1	50	60	0	0
	2	47-50	75	20	10
	1	64	75	50	30
	1	53	80	0	10
	1	53	90	100	40
Velsicol AR-50-fuel oil solution	1	52	8 pounds per acre	0	0
	TDE				
Acetone solution	1	52	35	0	0
	1	52	50	0	0
	1	50	60	0	0
	2	47-50	75	0	0
	1	64	75	40	0
	1	48	80	30	0
	1	53	90	100	20
Velsicol AR-50-fuel oil solution	1	52	8 pounds per acre	0	0
	Methoxychlor				
Acetone solution	1	50	10	0	0
	1	51	20	0	0
	1	53	25	0	0
	2	48-55	30	10	0
	2	52	35	40	50
	1	56	50	80	40
	Parathion				
Acetone solution	2	49-53	5	5	0
	2	53-49	7	10	0
	2	53-55	10	10	45

REPELLENTS AND PROTECTIVE CLOTHING

K. H. Applewhite, C. N. Smith, G. E. Nielsen, W. C. Frohne,
Robert L. Rittgers, Harold E. Kent, Pete Schulick, and
Dean D. Hesketh

In extensive, sparsely inhabited regions such as Alaska, it is impracticable or impossible to apply area control measures for the protection of individuals from insect attacks, except possibly around fixed military installations or civilian communities. Even here large-area treatments were effective for only a short period and must be repeated four or more times each season to insure satisfactory protection. Outside of such areas the protection of individuals is wholly dependent upon the use of repellents and protective clothing. Under these conditions it is desirable to have a repellent that is long-lasting and may be used with safety on the skin or clothing. A number of repellents and repellent mixtures which had shown outstanding effectiveness in tests at Orlando, Fla., or elsewhere, were selected for field testing in Alaska. These were tested as skin treatments and as clothing impregnations at several localities in order to evaluate them against as many different species of mosquitoes as possible. Skin tests were also made at Valdez where sand flies or punkies (Culicoides) were extremely abundant to determine the effectiveness of the repellents against these pests. The results of the various tests are described in this report.

Mosquito Tests

Skin Applications

All liquid repellents were tested at a concentration of 25 percent in alcohol, rather than at full strength. Tests at Orlando had shown that reliable evaluations of repellents could be made in this manner with shorter exposures than required for full-strength applications. The method was particularily desirable in Alaska because of the limited time and manpower available, and because of the variation in insect activity over a prolonged period due to changes in temperature and wind velocity.

Materials were tested on the arms, 1 cc. of 25-percent repellent solutions being applied over the forearm from wrist to elbow. Nine subjects were used in testing 10 materials, each testing 2 repellents at one time, one on each arm. Each repellent was tested once on each subject and paired once (tested on opposite arms of the same subject) with each of the other materials. This involved five different rounds of exposures, usually two per day, one in the morning and another in the afternoon. Exposures were made in localities where mosquitoes were numerous and where the biting rates on untreated arms were adequate for the tests. Protection time was figured to the first confirmed bite (i.e., confirmed by a second bite within 30 minutes).

In tests in the Anchorage area against Aedes flavescens, table 21, propyl N,N-dipropylsuccinamate was by far the most effective of 10 materials tested, with a protection time (for quarter-strength applications) of more than 178 minutes. Five other materials were about equal in effectiveness, with average protection times of 113 to 117 minutes, and the other four were effective for 82 to 102 minutes.

Table 21.--Relative effectiveness of liquid repellents as skin treatments against Alaskan Aedes. Anchorage, Alaska, June 29 to July 3, 1948, (9 tests each); Big Delta, Alaska, July 8-12 (9 tests each) and July 16-18 (5 tests each).

Code No.	Repellent	Minutes to first bite 1/			
		Anchorage		Big Delta 2/	
		Range	Average	Range	Average
0-9	Indalone	43-226	117	8-87	34
				14-67	32
0-262	Dimethyl phthalate	19-147	102	16-213	94
				41-198	140
0-375	Rutgers 612	37-170	115	17-126	71
				65-214	170
0-5533	4-(p-Methoxyphenyl)-5-methyl-1,3-dioxane	8-212	113	9-123	40
				8-98	56
0-5542	2,2'-Thiodiethanol diacetate	29-212	113+	9-121	42
0-6154	Pentamethylene propionate	10-198	92	10-93	37
0-6168	Propyl N,N-dipropylsuccinamate	9-334+	178+	12-174	92
				24-339	154
0-6216	Ethyl beta-phenylhydracrylate	34-142	82	6-160	50
0-7090	Butyraldehyde, 2-ethyl-2-nitro-1,3-propanediol acetal	10-197+	88+	6-91	24
M-250	Orlando 6-2-2 mixture (Dimethyl phthalate 60%, Rutgers 612 20%, and Indalone 20%)	15-175	114	34-123	76
				35-288	167

1/ Plus signs indicate termination of one or more of the tests before the first bite was received.

2/ Results are shown for two series of tests at Big Delta with 6 of the compounds.

In the Big Delta area against Aedes excrucians, A. communis, and A. pionips, all of the repellents were less effective than in the tests at Anchorage, some showing less than half the protection time. Propyl N,N-dipropylsuccinamate and dimethyl phthalate gave the best results, with protection times of 92 and 94 minutes, respectively. The next most effective repellents were Orlando 6-2-2 mixture, and Rutgers 612, both of which were among the six best materials at Anchorage.

In another series of tests at Big Delta, under somewhat different weather conditions, the six most effective repellents were retested. They were tested once on each of five subjects and paired once with each of the other repellents. In this series Rutgers 612 and the 6-2-2 mixture were equally effective and superior to the other four. Propyl N,N-dipropylsuccinamate and dimethyl phthalate were slightly less effective, whereas Indalone and 4-(p-methoxyphenyl)-5-methyl-1,3-dioxane were definitely inferior. Even though a much longer protection time was afforded with five of the materials in this test than in the previous one at Big Delta, the same four repellents were the most effective.

In a series of tests at Big Delta and Eielson Field with mixtures of the more effective repellents (table 22), a mixture containing 6 parts of dimethyl phthalate, 4 parts of propyl N,N-dipropylsuccinamate, 2 parts of Indalone, and 2 of Rutgers 612 was the most effective. Propyl N,N-dipropylsuccinamate alone was superior to the mixture containing Rutgers 612 and as effective as the mixture containing Indalone.

Table 22.--Relative effectiveness of three liquid repellent mixtures as skin treatments against Alaskan *Aedes*. Big Delta and Eielson Field, Alaska, July 16-18 1948. (Each tested once at 3 subjects.)

Repellent	Minutes to first bite: Range	Minutes to first bite: Average
Dimethyl phthalate, 6 parts Indalone, 2 parts Rutgers 612, 2 parts Propyl N, N-dipropylsuccinamate, 4 parts	147-273	189
Dimethyl phthalate, 6 parts Indalone, 2 parts Propyl N,N-dipropylsuccinamate,2 parts	72-300	168
Dimethyl phthalate, 6 parts Rutgers 612, 2 parts Propyl N,N-dipropylsuccinamate,2 parts	87-173	124
Propyl N,N-dipropylsuccinamate	111-215	167

In a small series of tests at Big Delta a proprietary cream containing dimethyl carbate substituted for Rutgers 612 in a 6-2-2 mixture was paired with the standard Orlando 6-2-2 mixture and two other repellents. The formula of the cream as given by the manufacturer was: 41.4% dimethyl phthalate, 13.8% each of dimethyl carbate and Indalone, 30% zinc stearate, and 1% bentonite. The results are shown below:

Repellent	Minutes to first bite
Proprietary cream	90
Orlando 6-2-2 mixture	86
Proprietary cream	159
Orlando 6-2-2 mixture	169
Proprietary cream	212[1/]
Orlando 6-2-2 mixture	206
Proprietary cream	249
Propyl N,N-dipropylsuccinamate	402

Repellent	Minutes to first bite
Proprietary cream	228[2/]
Propyl N,N-dipropylsuccinamate	228[1/]
Proprietary cream	321
Test mixture (dimethyl phthalate, 6 parts; Propyl N,N-dipropylsuccinamate, 4 parts; Rutgers 612, 2 parts; and Indalone, 2 parts)	239

1/ Unconfirmed first bite.
2/ No bites.

Another series of tests was conducted at Anchorage with a group of cream repellents prepared by the Chemical Corps. The principal species present was *Aedes flavescens*. In these tests 25 percent alcoholic solutions of the repellents were compared with the same compounds in creams consisting of approximately 20 percent repellent, 12 percent glycerol, 5 percent Dow Resin Blend 45, 5 percent bentonite, and 58 percent water. In 18 tests the creams were slightly less effective than the liquids. Since the liquids would normally be used at full strength, it was obvious that they would be much more effective than the cream preparations.

In general, propyl N,N-dipropylsuccinamate was more effective against Alaskan *Aedes* than any of the other repellents tested. In the three series of tests it was outstandingly more effective in one, and about as effective as any in the other two, from the standpoint of average time to first bite. Following this compound in effectiveness there was apparently no significant difference between dimethyl phthalate, Rutgers 612, and the Orlando 6-2-2 mixture. Indalone and 4-(p-methoxyphenyl)-5-methyl-1,3-dioxane gave good results in the first series but were considerably less effective in the other two. Average protection time for all tests for the six repellents that gave the best results in the first series are as follows:

Orlando code No.	Repellent	Average minutes to first bite
0-6168	Propyl N,N-dipropylsuccinamate	139+
M-250	Orlando 6-2-2 mixture	112
0-375	Rutgers 612	110
0-262	Dimethyl phthalate	107
0-5533	4-(p-Methoxyphenyl)-5-methyl-1,3-dioxane	72
0-9	Indalone	66

Clothing Applications

Cotton stockings impregnated with repellents were tested for durability of the treatments through aging, rinsing in water, and wearing. Thirty-five repellents that were outstanding in previous tests against salt-marsh mosquitoes were used. The stockings were impregnated with 3 grams of repellent per square foot of cloth (6.6 grams per stocking). dissolved in acetone (50 cc. per

stocking). After evaporation of the acetone, stockings were placed in individual paper bags, and were removed only for rinsing or testing.

In the aging tests the stockings were tested at intervals to determine the duration of effectiveness. In the rinsing tests the stockings were immersed in cool water, stirred for a few seconds, then wrung by hand (repeated five times at each rinsing). In the wearing tests, the stockings were tested after each 8 hours of wear. As the time available for testing was short, the effect of wearing was hastened by rinsing after 8 hours of wear in one series of tests, and after 8 and 16 hours in another.

Stockings were tested for effectiveness by exposing them for 10 minutes on the arms or legs of subjects in areas of heavy natural infestation. Before testing, bare arms or legs were exposed to determine that the biting rate was satisfactory. At each test, each stocking was tested on three subjects in succession, and was considered effective if the average number of bites per subject was less than five.

Results in the rinsing and wearing tests are shown in table 23. Compounds effective after an average of four rinsings and 16 hours of wear were Indalone; 2-[2-(2-ethylhexyloxy)ethoxy]ethanol; N-butyl-1,2,3,6-tetrahydrophthalimide; caprylic acid; isobornyl 4-morpholineacetate; allyl alpha,beta-epoxy-beta-phenylbutyrate; N-butylhexahydrophthalimide; acetamide, alpha,alpha,alpha-trichloro-N-(2-chloroethyl)-; cyclohexanepropionic acid; and hexyl mandelate. The last named repellent was slightly superior to most of the others in resistance to wearing, and withstood 13 rinsings in one test but only 4 in another. The next most resistant materials were alpha-butoxy-N-cyclohexylacetamide, Indalone and, 2-[2-(2-ethylhexyloxy)ethoxy]ethanol in the wearing tests, and cyclohexanepropionic acid in the rinsing tests. Several of the other materials were only slightly less resistant to rinsing or wearing than those named. The four most effective repellents on the skin made comparatively poor showing in these tests.

All repellents were effective after 12 days of aging, and no later tests were made.

Table 23.--Durability of mosquito repellents impregnated in cotton fabrics. Anchorage, Alaska, June 30 to July 13, 1948; and Big Delta, Alaska, July 8-24, 1948.

Code No. O-	Repellent	Number of rinsings withstood: Series 1 (Anchorage)	Number of rinsings withstood: Series 2 Big Delta)	Hours of wear withstood 1/: Series 3: (Rinsed after 8 hours)	Hours of wear withstood 1/: Series 4 (Rinsed after 8 & 16 hours)
	Repellents effective after an average of 4 rinsings and 16 hours of wear				
9	Indalone	6	4	24+	32
300	2-[2-(2-Ethylhexyloxy)ethoxy]ethanol	5	5	24+	32
4145	N-Butyl-1,2,3,6-tetrahydrophthalimide	4	4	24+	16
4162	Caprylic acid	4	6	16	16
4202	Hexyl mandelate	13	4	24+	40+
4262	Isobornyl 4-morpholineacetate	6	3	24+	16
7121	Allyl alpha,beta-epoxy-beta-phenylbutyrate	5	4	24+	16
7409	N-Butylhexahydrophthalimide	6	4	24+	16
8606	Acetamide, alpha,alpha,alpha-trichloro-N-(2-chloroethyl)-	6	5	24+	24
14244	Cyclohexanepropionic acid	7	7	8	24
	Repellents not effective after averages of 4 rinsings and 16 hours of wear				
262	Dimethyl phthalate	3	3	16	16
301	2-(2-Hexyloxyethoxy)ethanol	2	0	8	8
375	Rutgers 612	2	1	8	16
614	alpha-Butoxy-N-cyclohexylacetamide	3	4	24+	40+
910	Ethyl indalone	4	1	24+	24
925	N-Amyl-alpha-butoxyacetamide	3	3	24+	16
949	Cinnamyl alcohol	3	2	16	16
2459	Dodecanal	3	2	8	8
3387	Butyl sulfone	3	0	24+	16
3775	2-Butyl-2-ethyl-1,3-propanediol	3	1	8	16
3960	2-Methylhendecanal	9	4	0	24
4562	Methyl amyl alpha-glyceryl ether	3	0	8	8
4841	alpha-(2-Butoxyethoxy)-N-cyclohexylacetamide	3	1	8	16
5508	N,N-Di-iso-amylacetamide	4	4	8	16
5563	1,2,3,4-Tetrahydro-2-naphthol	2	4	8	16
5883	p-sec-Butoxybenzyl alcohol	4	1	24+	16
6168	Propyl N,N-dipropylsuccinamate	2	1	8	8
6216	Ethyl beta-phenylhydracrylate	3	2	8	16
6217	Isopropyl beta-phenylhydracrylate	3	2	24+	8
6220	Methyl beta-phenylhydracrylate	1	0	8	8
6378	1,3-Propanediol monobenzoate	3	1	8	8
12142	5-Ethyl-2,4-heptanediol	3	1	8	8
12144	2,4-Decanediol	3	2	24+	16
13039	2,3-Octanediol	3	1	8	8
M-250	Orlando 6-2-2 mixture (Dimethyl phthalate 60%, Rutgers 612 20%, and Indalone 20%)	3	4	24+	16

1/ Plus signs indicate stockings still effective when last tested.

Punkie (Culicoides) Tests

Tests against sand flies or Culicoides were conducted at Valdez, Alaska, where the predominant species was *Culicoides tristriatulus* Hoffman.

Skin Applications

The testing procedure against Culicoides was identical with that used against mosquitoes, except that the repellents were tested at full strength. One test was run with 25-percent solutions of the repellent in ethyl alcohol, and the protection time was so short that it was impossible to show any marked difference between repellents.

Of the nine repellents tested (table 24) none gave adequate protection. Dimethyl phthalate and the Orlando 6-2-2 mixture were the most effective materials, with protection times of 42 and 49 minutes, respectively. The remaining seven repellents were effective for an average of 15 to 30 minutes. In all cases the minimum time to the first bite was extremely low, ranging from 1 to 7 minutes.

Table 24.--Relative effectiveness of liquid repellents as skin treatments against *Culicoides tristriatulus*. Valdez, Alaska, July 15-16, 1948. (Nine tests of each repellent on different subjects.)

Code No.	Repellent	Minutes to first bite: Range	Minutes to first bite: Average
M-250	Orlando 6-2-2 mixture	3-105	49
0-262	Dimethyl phthalate	5-94	42
0-7090	Butyraldehyde, 2-ethyl-2-nitro-1,3-propanediol acetal	3-83	32
0-6216	Ethyl beta-phenylhydracrylate	7-62	28
0-6168	Propyl N,N-dipropylsuccinamate	1-88	27
0-375	Rutgers 612	1-42	18
0-5542	2,2'-Thiodiethanol diacetate	6-27	17
0-6154	Pentamethylene propionate	2-52	17
0-9	Indalone	1-35	15

Impregnated Face Masks

Face masks of 6-, 8-, and 10-mesh cotton netting were treated with repellents and tested for ability to protect the face from Culicoides. The masks resembled small, closely fitting head nets, but were made with openings at the eyes to permit better vision and at the mouth to permit smoking or eating. Masks were treated with 2 grams of repellent in acetone solution per square foot of cloth, estimated exclusive of the area of the interstices. Four repellents that had given the best results in skin applications were used. Two masks of each mesh were treated with each repellent.

Tests were made by five subjects, wearing masks of the same mesh, four being treated with the various repellents and one untreated. Counts were made of the Culicoides which penetrated the masks and bit. When 25 bites had been counted on the subject wearing an untreated mask, tests were discontinued. Exposure periods required to secure this number varied from 4 to 16 minutes.

None of the masks gave adequate protection, although biting was reduced to some extent. Most of the penetration of the masks by Culicoides was through the mesh of the fabric rather than through the eye or mouth openings. With the finest mesh, averages of the two replications showed from 2 to 4 bites received in 6 to 16 minutes. Detailed results were as follows:

	Average number of bites (2 replications)		
	6-mesh	8-mesh	10-mesh
No treatment	25	25	25
Propyl N,N-dipropylsuccinamate	4	11	4
Ethyl beta-phenylhydracrylate	7	4	2
Dimethyl phthalate	6	1	2
Orlando 6-2-2 mixture	1	8	2

CLIMATIC STUDIES

R. L. Pratt, B. L. Morris, and G. J. Daley

During the spring and summer of 1948 special studies were made of the relation of temperature to breeding of mosquitoes and black flies, and the effect of various meteorological factors on the activity of mosquito and Culicoides adults. Observations were also made on the effect of wind and lapse rates on the dispersion of aerial sprays. A resume' of the findings on each of these phases of study is given under the appropriate headings, and the detailed data will be given in a supplemental report.

General Weather Data

In the Anchorage area, monthly mean temperatures were 5.2° to 9.4° above normal from November through January, but from February through April, 3.9° to 6.6° below normal, resulting in a late thaw. Precipitation was about normal through March, somewhat deficient from April through June, and slightly above normal from July through September. The total precipitation for the 9-month period from January through September, however, was approximately normal (10.3 inches).

In the Fairbanks area, the weather was unusually warm during November and December, but from January through April mean temperatures were from 4.2° to 6.9° below normal, resulting in a late thaw. The temperatures were close to normal during May and June, and considerably below normal from July through September. Precipitation was below normal for January, normal during February and March, well above normal from April through August, and below normal for September. For the 9-month period precipitation was about 60 percent in excess of the normal of 9.8 inches.

Stream Temperatures

Three typical black fly breeding streams were selected for a study of the daily and seasonal variations in temperature. Additional records were obtained for several other streams at about weekly intervals during the spring, summer, and early fall.

The regular study streams were Otter Creek, Little Otter Creek, and the outlet to Lower Fire Lake. Otter Creek, an outlet stream of Otter Lake, was about 8 feet wide and 1 foot deep, with a typically rocky bed. The outlet stream of Lower Fire Lake was similar to Otter Creek. Little Otter Creek, an inlet stream of Otter Lake, originated from springs in a large bog between glacial moraines. This stream was about 4 feet wide and 2 feet deep, with a mud bottom almost free of rocks.

Stream temperatures were taken by means of maximum and minimum thermometers mounted on Townsend supports which were placed on 2- by 4-inch stakes driven into the stream bed. Thermometers were established in Little Otter Creek about 1 mile above Otter Lake, and in Otter Creek about 1/2 mile below the lake. The thermometer in the outlet of Lower Fire Lake was placed about 100 yards below the lake. Records were started on April 14 in the three study streams, but those for the outlet stream of Lower Fire Lake had to be made beneath the ice covering until it cleared on April 27. The temperature beneath the ice in this stream was 32° F. at each reading.

The daily maximum and minimum temperatures in Otter Creek, an outlet of Otter Lake, and in the outlet stream of Lower Fire Lake closely paralleled the daily maximum and minimum air temperatures. The diurnal range of temperatures, however, was not as great for the streams as for the air. The diurnal range of temperatures in Otter Creek was somewhat greater than in the outlet for lower Fire Lake. This difference in the two streams probably was due to the fact that Otter Lake was larger and shallower, and therefore absorbed heat from the sun more readily than the smaller and slightly deeper Lower Fire Lake. The fact that temperatures were taken at different distances from the lakes may also have had some bearing on the differences in temperatures. The temperatures in both these lake-outlet streams were considerably higher and much more closely correlated with air temperatures throughout the season than those in Little Otter Creek, which was fed by springs. Weekly observations in another spring-fed stream and in a typical mountain stream also showed consistently low temperatures, ranging from 35 to 43° F. in the former and from 33 to 42° in the latter during the period from May to October.

Pool Temperatures

A study was made of the formation and temperatures of various types of mosquito-breeding pools, including the vertical and horizontal gradients of the pools. The greater part of this study was made in the vicinity of Ft. Richardson in Otter Lake Swamp and the Eagle River Flats. The study pools ranged in depth from 1 or 2 inches to 12 or 15 inches. Temperatures were taken with standard mercury thermometers, except in the study of vertical gradients when minimum thermometers were used.

After pools thawed early in April, temperatures below 32° F. were recorded nightly until May 18, and occasionally thereafter until June 8, although maximum daily temperatures were usually well above freezing. A diurnal overturn of the vertical temperature gradients in pools resulted when the water temperatures at night fell below 39.2°, at which water is most dense. Under these conditions it was found that the change in temperatures was slight on the bottoms of pools, moderate at middle depth, and great on the surfaces. This overturn of temperatures at different depths resulted from the tendency of water of the greatest density to displace lighter water. It is therefore evident that a pool may be ice-covered and still show a temperature of approximately 39.2° near the bottom. This condition, however, was observed only after the bottoms of pools were entirely free of ice and at times of strong solar radiation.

Studies of the horizontal gradients in pools revealed a wide range of temperatures. The sections of pools receiving the most solar radiation thawed first and also showed the highest temperatures. Frequently one part of a pool was frozen while only a few feet away the water was considerably above freezing. In one instance a 24° gradient was observed within 3 feet of a frozen section of a pool. Where horizontal temperature gradients existed, mosquito larvae invariably congregated in the warmest water.

Frequent observations were made in 26 pools located at Eagle River Flats and Otter Lake Swamp to study the relationship of pool temperatures to mosquito larval development. Warm, intermediate, and cold pools, in close proximity to each other, were included in this study. In general, differences in the temperatures of the pools were due to differences in the degree of shading from surrounding vegetation, in depth of water and in the amount and type of bottom cover.

There was great variation in temperature between pools, particularly in Otter Lake Swamp where the seasonal averages showed a range of 17°, from 36.3° to 53.3° F. During the last week of May the average temperature in one pool was 35.3° and in another pool 58.5°, or a difference of 23.2°. As would be expected, mosquito larvae appeared earlier and developed more rapidly in the warm pools than in the intermediate or cool pools. In the warmer pools larvae developed from newly hatched larvae to adults in about 31 days, while in cold pools, about 43 days were required.

Effect of Meteorological Factors on Mosquito Activity

A study was made of the effect of various meteorological factors on adult mosquito activity near Ladd Air Force Base during the last half of June. Observations were made in four different environments, namely, a small, open swamp, an open gravel area, an area with shrubbery and small spruce, and a spruce forest, all of which were within 100 feet of weather instruments. Normal but variable weather prevailed during this study.

Mosquito activity was determined by adult landing rates and by "net" counts. The latter were made by swinging a 14-inch net a set number of times at various heights from the ground and counting the adults collected. Landing rates were taken at two stations, one in the open and one in the spruce forest, and each consisted of four counts of adults on the clothing after 68-second exposure periods. Two of the counts were made on the back of one person, once with the back to the wind and once away from the wind, and one count each on the front and back of the trousers. While the counts were being made, data were obtained on wind velocity, lapse rates from the ground to a height of 14 feet, relative humidity, and solar radiation. Observations were also made on cloudiness, precipitation, and other weather phenomena. Tabular summaries of the relation of mosquito activity to wind velocities, temperatures, and lapse rates are given in table 25.

Wind velocity was found to have a marked effect upon adult mosquito activity. The counts were rapidly reduced as wind speeds were increased from 0.5 to 2.5 m.p.h., but tended to level off at higher velocities up to 5 m.p.h. In this connection, it was observed that some species of mosquitoes were less affected by wind than others. At times of greatest adult activity *Aedes communis*, *A. punctor*, and *A. intrudens* comprised the bulk of the population, while with high wind velocities *Aedes excrucians* and *A. impiger* predominated. Landing rates were lower on the windward side of subjects than on the side protected from the wind, and were somewhat lower on the back than on the trousers as wind velocity increased.

Landing counts of mosquitoes were very low at temperatures below 44° F. and above 85°. The peak of adult activity occurred between 55° and 65°. It was not determined whether temperature or humidity was the major factor governing adult activity. On several occasions fairly large numbers were active at temperatures below 80° when humidity was very low. Adult activity was greatest when relative humidity was between 55 and 70 percent, about average above 70 percent, and below average at less than 40 percent. Statistical analyses of the data have not been made but from inspection there did not appear to be a significant correlation between humidity and adult activity.

Table 25.--Correlations of mosquito counts with wind velocity, temperature, and temperature lapse rates.

	Number of observations	Average total count
Wind velocity (m.p.h.)		
0	18	157
0.1-0.4	19	165
.5-0.9	18	132
1.0-1.4	29	91
1.5-1.9	12	56
2.0-2.9	8	51
3.0-3.9	11	35
4+	3	34
Total	118	106
Temperature (°F.)		
35.0-44.9	3	11
45.0-54.9	37	117
55.0-64.9	34	154
65.0-74.9	21	88
75.0-84.9	14	65
85.0-95.0	9	25
Total	118	106
Lapse rate 1/		
+14 to 10	6	173
+9 to 5	17	186
+4 to 0	46	101
-1 to -5	20	88
-6 to -9	9	62
-10	10	30
Total	108 2/	106

1/ Increase or decrease in temperature from the ground to 14-foot elevation indicated by plus and minus signs.

2/ 3 counts at temperatures below 45° omitted; records not taken for 7 other counts.

A very close correlation was indicated between mosquito activity and temperature lapse rates from the ground to a height of 14 feet. Landing rates were highest when the air temperatures were higher than the ground temperature (inversion), and decreased as air temperature decreased below that of the ground. When the ground temperature was low and inversion strong, considerable activity was observed above head level. Large numbers of adults were to be found among the branches of 25-foot spruce trees. When ground temperatures were high, adults tended to remain on or near the ground in cool places, and at such times they showed little interest in biting.

Studies were made on the effect of solar radiation on mosquito activity when wind velocities were less than 1 m.p.h, and from 1 to 2 m.p.h. The peak of adult activity occurred during bright twilight or other times of moderately low radiation. The least activity occurred during bright sunlight, but other prevailing conditions, such as low humidity, strong winds, or higher lapse rates doubtless had considerable bearing on the reduction in activity. The same conclusion was drawn in another study on the relationship of pressure tendencies to adult activity. When winds were light, activity was greater when the pressure was rising than when falling. Little difference was noted in mosquito activity when the sky was clear or overcast, or when a light rain was falling.

Effect of Meteorological Factors on *Culicoides* Activity

Culicoides tristriatulus was extremely abundant and annoying in the vicinity of Valdez, and a study was made during the period July 3 to July 13 to determine the effect of various meteorological factors on adult activity. Valdez is situated at the end of Valdez Arm about 50 miles inland from Prince William Sound. The terrain is mountainous except for extensive tidal flats, which are apparently the principal source of *Culicoides* breeding. During the summer there is a strong wind from the sea in the daytime, but at night the wind reverses. The daytime winds range from 4 to 8 m.p.h. on overcast days up to 25 m.p.h. on clear days. The nighttime winds are light, ranging from 1 to 3 m.p.h.

For this study, weather instruments were established on the tidal flats about 1/2 mile from the shore at low tide, and at about the normal shore line of high tides. As in the mosquito studies detailed data were obtained on wind velocity and direction, pressure tendencies, temperatures, and lapse rates from the surface to a height of 14 feet. Observations were also made on cloud conditions, precipitation, and solar radiation. *Culicoides* activity was estimated at regular intervals by counting the adults landing on an observer's hat after a 2-minute waiting period. The correlation of adult activity with wind, temperature, and lapse rates is shown in table 26.

The results of the studies showed that *Culicoides* activity is greatly influenced by wind, the counts being highest at wind velocities of 1.5 to 1.9 m.p.h., and was near or slightly above average at velocities less than 1.5 and between 2 to 3.4 m.p.h. Very few adults were active at wind speeds of 3.5 m.p.h. or greater.

Temperatures ranging from 50° to 59° F. were most favorable for *Culicoides* activity, while very few adults were counted below 44° and above 60°. The lack of activity at temperatures of 60° or higher was attributable to consistently high winds during the warmer parts of the day.

Table 26.--Correlation of Culicoides counts with wind velocity and temperature.

	Number of observations	Average count
Wind velocity (m.p.h.)		
0	28	90
0.1-0.4	23	60
.5-0.9	21	103
1.0-1.9	25	148
2.0-2.9	27	82
3.0-3.9	18	64
4.0-4.9	9	11
5.0+	21	.05
Total	172	77
Temperature (°F.)		
40-44	4	3
45-49	29	41
50-54	74	105
55-59	49	89
60-64	16	6
65+	2	0
Total	174	77

It was further observed that activity was greatest during the twilight hours and least during darkness and bright sunlight. However, with winds of less than 3 m.p.h., increased activity appeared to be correlated with increasing radiation, as the average of counts in the sunlight was twice that for all observations, and three times that during dusk or darkness. It was therefore concluded that the wind accompanying sunlight was primarily responsible for reduced Culicoides activity, rather than solar radiation. In this connection it is also significant that Culicoides refused to enter the tent, jeep, or other shady places.

Maximum Culicoides activity occurred when relative humidity ranged from 90 to 94 percent, and activity was much reduced at lower humidities. The decline of activity during periods of low humidity, however, may have been due chiefly to accompanying high temperatures and winds. Pressure tendencies did not appear to have an appreciable effect on Culicoides activity.

There were two daily peaks of adult activity, the higher one usually from 5 to 6 p.m. and the other from 5 to 8 a.m. In between these times the counts frequently dropped to zero during the middle of the day and around midnight. The time of maximum activity varied considerably, depending chiefly upon winds. On July 8 winds ranging from 3.2 to 8.6 m.p.h. occurred from 10 a.m. to 9 p.m., and the Culicoides counts were mostly zero. At 10 p.m. the wind dropped to 1.6 m.p.h. and a count of 600 was obtained, the highest count in the entire series. Counts of 450 and 300 were recorded at 11 and 12 p.m., after which there was a drop to less than 50.

Effect of Meteorological Conditions on the Effectiveness of Aerial Sprays

Detailed meteorological data were obtained during 40 spraying runs at six locations to determine the influence of several factors on the effectiveness of aerial sprays for the control of mosquitoes. Excellent control was obtained under a wide variety of conditions, including extreme lapse rates, moderate winds, and even light rain. In one instance 99-percent control of larvae was obtained when the average lapse rate was -32° F. (temperature of 114° on the ground and 82° at the 8- and 14-foot levels). During this time the wind varied from 1 to 6 m.p.h. Control was slightly less when the lapse rate averaged only -2° but were accompanied by winds of 7 to 13 m.p.h. Under the conditions encountered it was indicated that high lapse rates did not affect results as much as expected.

Data were collected at Eielsen Field to compare the size of spray droplets reaching the ground under different temperature gradients. Droplets reaching the ground varied from 17 to 238 microns in diameter, the mass median being 136 microns. Slightly fewer droplets in the 17- to 22-micron range reached the ground when the air temperature was lower than the surface temperature, but the decrease was not significant.

VEGETATION STUDIES

Ernest LePage

A detailed study was made of the vegetation in mosquito-breeding areas at 21 stations in the vicinity of Anchorage and Fairbanks. The study stations included all the types of mosquito-breeding areas occurring in the middle and low subarctic zones of Alaska.

The vegetation is rarely uniform at any station, but is rather a complex of many plants or plant associations, which are not equally suitable for mosquito breeding. Consequently, after the plant listing showing the general pattern of the vegetation, a tentative list is given of the plants that appear to be indicators of mosquito breeding habitats. Finally, a list of flowering dates of marshland plants is given.

Detailed Studies

Station 13, Eagle River Flats.--See Alaska Report, 1947 (p. 88).

Station 14, head of Otter Lake, Anchorage.--This spruce-heath bog is formed on the west side of Otter Lake.

On the lower part:

Myrica Gale
Carex limosa
Mosses (Drepanocladus sp. and Calliergon sp.)

On the rest of the station:

Picea mariana (small and dwarfed)
Picea glauca (by the shore)
Betula nana ssp. exilis
Myrica Gale
Andromeda Polifolia
Ledum groenlandicum
Vaccinium Vitis-idaea
Empetrum nigrum
Calamagrostis canadensis
Eriophorum brachyantherum
Camptothecium nitens (moss)
Sphagnum sp.

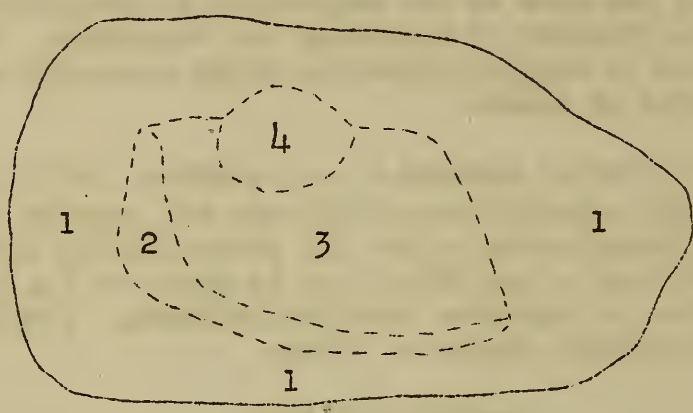
Station 20.--Adjacent to Spenard Road. Sphagnum-Drepanocladus marsh with:

Chamaedaphne calyculata
Andromeda Polifolia
Betula nana ssp. exilis (few)
Eriophorum brachyantherum
Eriophorum Chamissonis var. albidum

Station 32, southwest of Anchorage.--Pool, 50 yards long (see graph 1).

1. Marginal zone of Calamagrostis canadensis with potholes.
2. Free water (5-12 inches deep) with floating Ranunculus Gmelini and Potamogeton sp.
3. Free water (12-18 inches deep) with Carex rostrata.
4. Free water with Menyanthes trifoliata.

Graph 1.--Station 32, southwest of Anchorage



Station 43, Eklutna Flats.--See Alaska Report, 1947 (p. 92).

Station 53, Fish Creek Flats.--Flood plain at the mouth of Fish Creek, west of Anchorage (see graph 2).

1. Margin of the creek

   Carex Ramenskii 90%
   Carex subspathacea
   Triglochin maritima
   Potentilla pacifica

2. Dry area

   Elymus arenarius
   Poa eminens
   Festuca rubra
   Carex Gmelini
   Atriplex Gmelini
   Potentilla pacifica
   Rosa acicularis
   Dodecatheon superbum
   Lathyrus palustris
   Achillea borealis
   Chrysanthemum arcticum
   Ligusticum Hultenii

3. Carex Eleocharis

   Carex Ramenskii 60-80%
   Carex pluriflora 15%
   Carex cryptocarpa (few)
   Eleocharis kamtschatica 15%
   Calamagrostis deschampsioides

4. Poa eminens
   Puccinellia sp.
   Salicornia herbacea
   Glaux maritima
   Triglochin maritima
   Plantago juncoides
   Potentilla pacifica
   Chrysanthemum arcticum

5. Eleocharis kamtschatica 100%

6. Scirpus pacificus 100%

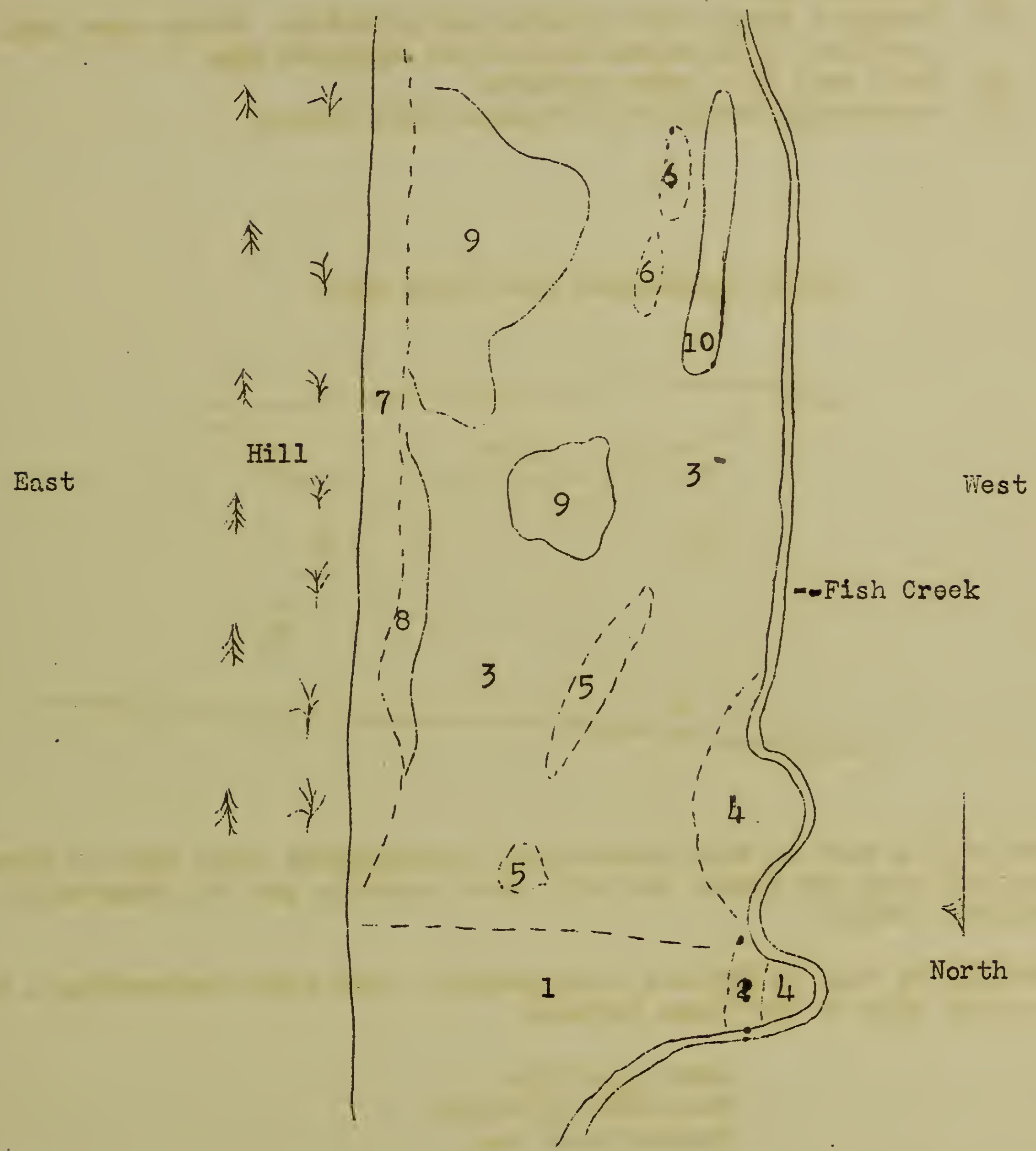
7. Myrica Gale 100%
   Calamagrostis canadensis (few)

8. Salix fuscescens and Betula nana ssp. exilis 50%
   Carex Ramenskii 50%

9. Same plants as 3, but with mat broken, enclosing black-ooze-bottomed pool

10. Barren, or with scattered Triglochin maritima.

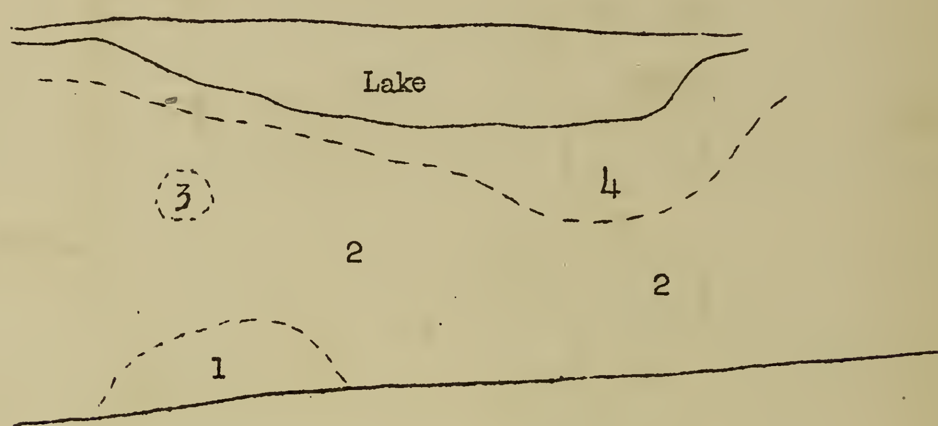
Graph 2.--Station 53, Fish Creek Flats.



Station 55-B, Fire Lake.--This bog is formed on the south side of lower Fire Lake and adjacent to the Glenn Highway (see graph 3).

1. Sphagnum spp.
2. Sphagnous heath with tussocks and potholes: Betula nana ssp. exilis; Chamaedaphne calyculata; sphagnum spp.
3. Small pool with Carex rostrata
4. Grass-sedge margin with Drepanocladus (moss).

Graph 3.--Station 55-B, Fire Lake



Station 56, east of Fire Lake.--Small sedge-marsh, south side of Glenn Highway, including two pools, one with Carex rostrata and the other with Drepanocladus (moss).

Station 60, east of Eklutna Flats.--Small Carex marsh surrounding a large pond on south side of the Glenn Highway:

Carex aquatilis
Potentilla palustris
Drepanocladus sp.

Station 104, road to College, 7.5 miles from Fairbanks.--Buckbean pool:

In deep water:

Menyanthes trifoliata (Buckbean)

In shallow water:

Potentilla palustris
Equisetum fluviatile

Station 105, road to College, 6.5 miles from Fairbanks.--Swampy margin of a pond:

Equisetum fluviatile
Carex aquatilis
Eriophorum angustifolium
Betula glandulosa

Station 108, road to College, 8 miles from Fairbanks.--Small sedge marsh:

Carex rostrata (mostly)
Carex physocarpa
Carex canescens

Station 154, east of Eklutna Flats.--South side of Glenn Highway: pool with Equisetum fluviatile and Potentilla palustris. North side of the road: small Carex marsh.

Station 504-B, Richardson Highway, 30 miles from Fairbanks.--Myrica-Andromeda-sedge marsh:

Myrica Gale
Andromeda Polifolia
Betula glandulosa (few)
Carex aquatilis

Station 506, Richardson Highway, 11 miles from Fairbanks.--Birch-sedge marsh surrounded by larch-spruce forest:

Shrubs:

Betula glandulosa
Chamaedaphne calyculata
Andromeda Polifolia
Salix sp.

Sedges:

Carex physocarpa (mostly)
Carex chordorrhiza

Sphagnum sp.

Station 507, Richardson Highway, 10 miles from Fairbanks.--Birch-spruce marsh crossed by caterpillar tractor tracks:

A. In car tracks. Free water covering 40% of the surface.

a. In the water:

Ranunculus Gmelini var. terrestris
Iris setosa ssp. interior
Carex aquatilis

b. Between the tracks:

1. Sedges:

Carex physocarpa (dominant)
Carex media
Carex disperma
Carex tenuiflora
Carex canescens

2. Cotton-grasses:

Eriophorum brachyantherum
Eriophorum medium
Eriophorum Chamissonis var. albidum
Eriophorum angustifolium

3. Grasses:

Arctagrostis arundinacea
Calamagrostis canadensis
Glyceria sp.

4. Horsetails:

Equisetum fluviatile
Equisetum palustre
Equisetum arvense

5. Other herbs:

Iris setosa ssp. interior
Potentilla palustris
Caltha palustris var. asarifolia
Luzula rufescens

6. Moss: Aulacomnium palustre

Dominant plants: Sedges, cotton-grasses, and grasses

B. Outside of the car tracks. The study of this part of the station was made by means of quadrats measuring 20 x 20 feet.

a. 1° quadrat south side of the tracks. Potholes 10% (free water):

1. Trees:

Picea mariana, 10-15 ft. high, 1,080 per acre
Spruce (dead), 1,600 per acre

2. Shrubs:

Betula glandulosa 30%
Chamaedaphne calyculata 30%
Salix sp. 30%
Vaccinium uliginosum 10%
Potentilla fruoticosa (few)
Ledum palustre (few)

3. Herbs (few):

Eriophorum brachyantherum
Carex aquatilis
Calamagrostis canadensis
Rubus Chamaemorus

4. Mosses:

Aulacomnium palustre (mostly)
Camptothecium nitens
Pleurozium Schreberi) drier places
Hylocomium splendens)

b. 2° quadrat north side of the tracks. Potholes 20%.

1. Trees (1-3 feet):

Picea mariana, 900 per acre
Larix laricina, 1,600 per acre
(No dead trees)

2. Shrubs:

Betula glandulosa 25%
Chamaedaphne calyculata 35%
Salix sp. 25%
Vaccinium uliginosum 10%
Potentilla fructicosa 5%

3. Herbs (few):

Equisetum fluviatile
Equisetum arvense
Equisetum palustre
Eriophorum brachyantherum
Arctagrostis arundinacea
Rubus arcticus
Potentilla palustris
Iris setosa ssp. interior
Petasites sagittatus

4. Mosses:

Sphagnum sp. 10%
Camptothecium nitens 45%
Aulacomnium palustre 45%
(These mosses cover the whole quadrat)

Station 514, road to College, 4 miles from Fairbanks.--Sedge pool with Chamaedaphne calyculata and Eriorphorum brachyantherum.

Station 515, road to College, 5.5 miles from Fairbanks.--Horsetail pool with Equisetum fluviatile (mostly) and Carex aquatilis.

Station 522, road to College, 4 miles from Fairbanks.--Swampy margin of a large pond, contains Carex rostrata and Glyceria sp.

Station 524, Richardson Highway, 8 miles from Fairbanks.--Horsetail pool with Equisetum fluviatile.

Station 525, Richardson Highway, 14 miles from Fairbanks.--Sedge pool:

Sedges:

Carex rostrata (mostly)
Carex aquatilis
Eleocharis aff. palustris

Horsetail: Equisetum fluviatile

Moss: Drepanocladus sp.

Table 27.--List of indicator plants for the mosquito-breeding areas.

Plants	Habitats	Mosquito-breeding ranges	Stations studied
Calamagrostis canadensis	Potholes	May-Sept.	20, 32, 56
Sphagnum spp.[1/]	Inland marshes	do.	43, 55-B, 153, 506, 507
Drepanocladus spp.) Calliergon spp.)	Pools, potholes, and lake margins	do.	20, 56, 60, 525
Camptothecium nitens) Aulacomnium palustre)	Inland and coastal marshes	May-June	14, 43, 507
Carex cryptocarpa	Coastal marshes	May	13, 43, 53
Carex Ramenskii) Carex pluriflora)	do.	May-July	53
Carex rostrata	Pool & lake margins	do.	32, 55-B, 56, 108, 522, 525
Scirpus pacificus) Eleocharis kamtschatica)	Coastal marshes	do.	13, 53
Triglochin maritima[2/]	Coastal marshes	do.	13
Menyanthes trifoliata	Pools & lake margins	June-July	32, 104
Equisetum fluviatile	do.	May-June	104, 105, 154, 515, 524

Table 27.--(Cont'd.)

Plants	Habitats	Mosquito-breeding ranges	Stations studied
Betula nana ssp. exilis) Salix fuscescens)	Coastal marshes	May-June	13, 43, 53
Chamaedaphne calyculata) Andromeda Polifolia)	Inland marshes	do.	20, 55-B, 504-B, 506, 507, 514
Myrica Gale	Coastal and inland marshes	May-July	13, 14, 43, 53, 504-B

1/ Because of the high absorption power of these mosses, the free water suitable to mosquito breeding often disappears about the last of May. Moreover, their high insulating power maintains the frost line close to the surface and water in nearby potholes remains relatively cold. A few species of semi-aquatic Sphagnum thrive in free water all summer and mosquito breeding may continue until the last of September.

2/ Triglochin maritima occurs in all coastal marshes, but rarely in pure formation.

Flowering Dates of Marshland Plants

Plants	Dates	Remarks
Alnus crispa ssp. sinuata	May 22-June 2	Heavy pollen
Alnus tenuifolia	May 24-June 2	do.
Andromeda Polifolia	May 31-June 7	
Anemone Richardsonii	May 25-June 9	
Betula nana ssp. exilis	May 26-June 2	do.
Caltha palustris asarifolia	May 26-June 9	
Carex cryptocarpa	June 1-June 9	
Carex pluriflora	June 2	
Chamaedaphne calyculata	May 24-June 1	
Eriophorum brachyantherum	May 28	
Eriophorum Chamissonis var. albidum	May 24-June 9	
Menyanthes trifoliata	June 1-June 20	
Myrica Gale	May 22-June 2	do.
Populus trichocarpa	May 21	do.
Ranunculus lapponicus	June 2-June 9	
Ribes rigens	June 1-June 7	
Rosa acicularis	June 7	
Rubus arcticus	May 26-June 9	
Rubus Chamaemorus	May 26-June 9	
Salix fuscescens	May 24-June 2	
Salix myrtillifolia	May 28	
Trientalis arctica	June 1-June 29	
Vaccinium Vitis-idaea	June 2-June 29	
Viburnum edule	June 1-June 9	

AIRPLANE EQUIPMENT

C. N. Husman, F. S. Blanton, B. V. Travis,
K. H. Applewhite, and R. L. Pratt

In March 1948 wing spray booms, which are now considered one of the standard types of installation, were designed for and installed on a C-47 plane. A similar installation had been made in 1947 on a Norseman (UC-64)1/ for use in Alaska. A check valve was also developed for the L-5 spray booms to prevent drainage of the spray bars when the supply valve was closed. A brief description of these installations and the calibration of each are given in this report.

Equipment for C-47

No structural changes in the C-47 plane were necessary for the installation of the spray boom, and it could be installed or removed in about 4 hours. The equipment caused no change in flight characteristics, but the drag therefrom reduced the cruising speed by 10 m.p.h.

The spray solution was carried in two rubber-lined, 375-gallon gasoline tanks mounted one behind the other in the front of the cargo compartment. Each tank was mounted on a separate wooden cradle, padded with rubber stripping. Each tank was secured to its cradle with cables and turnbuckles, and each cradle was bolted to the floor of the cargo compartment.

The spray system consisted of two wing booms, each 18 feet long, and one center-section boom 8 feet 6 inches long constructed of chrome-molybdenum-steel tubing of 1.25-inch (o.d.) by 0.035-inch wall thickness. Spray-outlet holes of No. 52 wire-drill size (0.064 inch) were spaced 2 1/2 inches apart the full length of each boom, on the back side. The booms were held securely in place by hanger brackets 18 inches below the wings and center section. The wing units were not rigid and therefore flexed with the wing. Drip-guard plates were installed on all hanger brackets to prevent spray material from working up the rear supports onto the ailerons.

The spray solutions were delivered from the tanks to the booms by five 24-volt, electric fuel-transfer pumps, each with a capacity of 850 gallons per hour at a pressure of 14 pounds per square inch. The pumps and an electric relay system were mounted on a platform secured to the cradle mount, two of the pumps being connected to each wing boom and one to the center-section boom. A switch box containing a control switch for each spray boom was mounted on the rear wall of the pilot's compartment within easy reach of the co-pilot. The supply line from each tank entered a manifold that had one outlet for each pump. A check valve was installed in the supply line from the rear tank, to eliminate drainage from the front to the rear tank. Aluminum tubing, 1 1/4-inches in diameter, connected the manifold to the spray booms. The connecting tubing extended through the radio-compartment floor and then through the de-icer doors on the bottom of the fuselage, making it unnecessary to cut the fuselage skin. All tubing connections were made with oil-resistant rubber hose and clamps.

The equipment was calibrated by flying the plane directly into the wind at an altitude of about 50 feet. Calibration runs were made with wind below 1 m.p.h. at a delivery rate of 1 pint per acre. White squared paper and glass slides coated with magnesium oxide were placed every 100 feet at right angles to the line of

1/Most of this installation was made by Captain Stevens, Ft. Richardson, Alaska.

flight, so that the swath width, droplet size, and the number of droplets reaching the ground per square inch could be determined. The spray solutions contained 0.5 percent of red dye for calibration purposes. The calibration data are given in table 28.

Table 28.--Calibration data for the C-47, the UC-64, and the L-5 with and without impinging plate. (Sprays containing 20% DDT, 40% Velsicol AR-50, and 40% fuel oil were used.)

Item	C-47	UC-64	L-5: With impinging plate	L-5: Without impinging plate
Air speed, miles per hour	140	120	90	90
Swath width, feet	800	300	100	100
Droplet size (mass median diameter), microns	136	156	98	224
Diameter of droplets (microns):				
0-50	18	17	39	23
51-100	59	45	52	33
101-150	17	24	8	20
151-200	6	16	1	17
201-250	.2	0	0	4
251-500	0	0	0	4
Delivery rate, gallons per minute	28.6 1/	9.1	2.3	2.3
Acres covered per minute	225.9	72.6	18.2	18.2
Pay load, gallons	600	100	42	42

1/Two pumps in operation, each with a capacity of 14.3 gallons per minute.

The number of droplets per square inch visible on the paper as determined from an average of two calibration runs with the C-47 are as follows:

Stations (100-foot intervals)	Average number of droplets per square inch
0	4
100	4
200	24
300	48
400	100
500	88
Center	
600	160
700	160
800	128
900	44
1,000	32
1,100	0

The electrical connections were arranged so that each pump could be operated separately. Each pump was capable of delivering 1/2 pint per acre, thus the delivery rate could be adjusted easily to give dosages ranging from 1/2 to 2 1/2 pints of solution per acre. When a dosage of 1/2 pint was applied, one pump was connected by a Y joint to both wing booms. In addition to this wide dosage range at the same air speed and swath width, the two supply tanks could be emptied independently. Therefore, two different spray solutions could be loaded at one time and sprayed in the same flight.

It was found that the center-section boom was not necessary to insure coverage of the central portion of the swath. Consequently, this boom was used only for applying the higher dosages.

In field tests the beginning of each swath was marked for the pilot by smoke bombs and the pilot then flew a straight line, using both a compass and scaled maps or scaled photographs. In each test a preliminary "dry run" was made to establish the compass course and to locate check points at the end of the run. This method not only proved satisfactory but was the only feasible way to maintain accurate swath intervals where runs were 4 to 5 miles long.

The original plans for construction of the equipment could not be followed because streamlined tubing and special solenoid valves were not available. The use of streamlined tubing for constructing the spray booms and hanger brackets would have minimized the drag and resulted in little or no loss of flying speed. In addition, a check valve similar to the one designed for the L-5 would stop drainage of the booms after the pumps are shut off, and thus prevent loss of spray material.

Equipment for UC-64

The UC-64, or Norseman, plane was equipped with 12-foot spray booms mounted on the struts under each wing. Six holes, No. 48 wire-drill size (0.076-inch), were spaced equidistant along each boom. The insecticide was carried in a 200-gallon tank, which was mounted in a wooden cradle and bolted to the floor of the cargo compartment. An electrically driven fuel pump (Pesco G-10) with a maximum delivery rate of 450 gallons per hour was used for the pressure system. The pump was equipped with an adjustable pressure by-pass valve, making it possible to alter the output. A toggle switch to operate the pumps was mounted on the instrument panel within easy reach of the pilot.

The calibrations (table 28) were made under the same conditions as for the C-47.

Equipment for L-5

The L-5 plane was equipped with the standard spray-boom equipment. Each boom had 10 holes, No. 70 wire-drill size (0.028-inch), all of which were used for dosages of 1 pint per acre. When dosages of 1/2 pint were needed, half the holes were closed with hose clamps.

A ball check valve with an adjustable tension spring was designed and mounted on each boom to eliminate the drainage of the spray solution from the lines after the tank valve was closed. The unit could be adjusted to hold back pressures of 5 to 20 pounds per square inch, as needed.

The L-5 equipment was tested both with and without impinging plates on the booms. The impinging plates lowered the mass median diameter and reduced the number of undesirable large drops (table 28).

BLOWFLIES (Calliphoridae)

R. I. Sailer, S. Lienk, and G. Jefferson

Several blowfly collections were made in the vicinity of Fairbanks between May 28 and June 14, and one large collection at Anchorage on August 9. All flies were caught in screen-wire fly traps baited with liver or dead salmon. Less than half of the collections have been studied to date, including those made at Fairbanks after June 17. The material was identified by Mr. D. G. Hall, Bureau of Entomology and Plant Quarantine, who also generously provided information concerning the possible importance of the various species of Alaskan blowflies.

Eight species of blowflies were represented in the eight collections so far examined (table 29). Of these, Protophormia terrae-novae appears most likely to have public health significance in Alaska. This species was present in seven of the eight collections, and the number of specimens exceeded the total of the seven other species. This species was abundant from late in May until about the middle of August. Lucilia illustris and Calliphora terrae-novae were the next most numerous species. Neither of these was taken before June 14.

Lucilia illustris and Calliphora terrae-novae are not known to have public health significance in the United States and probably have little in Alaska. Protophormia terrae-novae, however, is of considerable importance in the United States, where it causes cutaneous myiasis in man and animals, contaminates human food, and lays eggs on fresh meat. Adults have also been collected in the field that were infected with the virus of poliomyelitis.

Table 29.--Species of blowflies collected.

Species	Fairbanks: Collections	Fairbanks: Specimens	Anchorage: Collections	Anchorage: Specimens
Calliphora mortica Shannon			1	10
terrae-novae Macq.	2	26	1	129
vicina R.-D.	1	3		
vomitoria (L.)	1	5	1	8
Cynomyopsis cadaverina (R.-D.)	3	13	1	23
Francilia alaskensis Shannon	3	18		
Lucilia illustris (Mg.)	1	61	1	34
Protophormia terrae-novae (R.-D.)	7	407	1	15

LIST OF ECTOPARASITES COLLECTED

J. D. Gregson

A number of small mammals were examined for fleas and ticks during the summer of 1948. The fleas were determined by Mr. Holland who makes the following statement: "The Hystrichopsylla gigas ssp. is referable to occidentalis, a manuscript name which will become available when the 'Siphonaptera of Canada' is published. The Megabothris asio n. ssp. will be described in the very near future. I already had material of this race from Aklavik, N.W.T." The ticks were identified by J. D. Gregson. All the shrew (Sorex) ticks were too immature to identify positively. From their size these larvae appear to be Ixodes angustus. In British Columbia the usual shrew tick is I. soricis Gregson. Similarly, the pika (Ochotona) in British Columbia has its specific tick, I. ochotonae Gregson. The specific ticks of these two animals are both close to angustus, a point of interest relating to the appearance of only the latter in Alaska.

The following is a list of these collections:

Kamloops, B. C. Lab. No.		Host and Parasites	Locality	Date (1948)
3271	1	Sorex sp. Ticks: 3 Ixodes angustus Neumann (?) larvae Fleas: None	Goose Bay	6/9
3272	1	Clethrionomys sp. Ticks: 1 I. angustus Neumann nymph Fleas: None	Cottonwood Cr.	6/10
3273	1	Citellus plesius Ticks: None Fleas: 2 males, 2 females, Oropsylla sp. near idahoensis (Baker)	Little Susitna	6/11
3274	1	Mus Musculus (No parasites)	Whitehorse	6/19
3275	1	Sorex sp. (No parasites)	Whitehorse	6/22
3276	16	Microtus sp. (reddish) Ticks: None Fleas: 1 male, 6 females, Malaraeus penicilliger dissimilis Jordan; 1 female Megabothris abantis (Rothschild); 3 males, 1 female, Megabothris asio n. ssp.	Naknek	6/28
3277	7	Microtus sp. (grey) (No parasites)	Naknek	6/28

Kamloops, B. C. Lab. No.		Host and Parasites	Locality	Date (1948)
3278	6	Sorex sp. Ticks: None Fleas: 4 females, Corrodopsylla curvata (Rothschild)	Naknek	6/29
3279	2	Clethrionomys sp. Ticks: None Fleas: 2 females, Malaraeus penicilliger dissimilis Jordan; 1 male, 2 females, Megabothris asio n. ssp.	Naknek	6/29
3280	1	Zapus sp. Ticks: None Fleas: 5 females, Megabothris abantis (Rothschild)	Naknek	6/29
3281		Clethrionomys sp. Ticks: 1 female, I. angustus Neumann Fleas: 2 males, 1 female, Catallagia charlottensis (Baker); 2 females, Megabothris abantis (Rothschild); 1 male, Hystrichopsylla gigas ssp.	Valdez	7/8-12
3282	22	Sorex sp. Ticks: 1 I. angustus Neumann (?) Fleas: None	Valdez	7/8-12
3283	2	Microtus sp. (grey) Ticks: None Fleas: 1 female, 1 male, Megabothris abantis (Rothschild)	Valdez	7/8-12
3284	2	Ochotona collaris Ticks: 4 I. angustus Neumann Fleas: 1 male, Thrassis spenceri Wagner	Thompson Pass	7/13
3285	2	Marmota sp. (No parasites)	Thompson Pass	8/13
3286	1	Citellus plesius (No parasites)	Thompson Pass	8/13
3287	1	Sorex sp. (No parasites)	Thompson Pass	8/13
3288	1	Sorex sp. Ticks: 3 I. angustus Neumann Fleas: None	Ft. Richardson	8/19
3289	1	Clethrionomys sp. (No parasites)	Ft. Richardson	7/19

Project Personnel - 1948

Capt. K. H. Applewhite, Entomologist, OQMG, Washington, D. C., March 3 to 5; June 12 to 20; and July 10 to September 9.

Maj. James E. Barnhill, Jr., QMC Supply Officer, Quartermaster Board, Camp Lee, Va., March 3 to September 9.

Major F. S. Blanton, MSC, Entomologist, Liaison Officer, Office of the Surgeon General, Washington, D. C., March 3 to August 26.

Lt. R. B. Carlson, Ft. Richardson, Alaska, Pilot as needed during season.

Cpl. Gene J. Daley, Army Weather Observer, on detached service from 7th Weather Group, Ft. Richardson, Alaska, March 22 to September 24.

Pfc. Joe W. Daugherty, Army Field Aid, on detached service from 183rd General Hospital, Ft. Richardson, Alaska, March 13 to September 13.

Pfc. Lewis H. Dover, Army Field Aid, on detached service from 57th Station, Medical Group, Ft. Richardson, Alaska, May 24 to October 27.

Dr. Charles O. Esselbaugh, Entomologist, USDA, BEPQ, Pullman, Washington, May 23 to September 21.

Maj. W. C. Frohne, Liaison Entomologist, USPHS, Manning, S. C., May 4 to August 13.

Pfc. Lee Gibson, Army Field Aid, on detached service from 183rd General Hospital, Ft. Richardson, Alaska, April 13 to July 20.

Mr. C. M. Gjullin, Entomologist, USDA, BEPQ, Corvallis, Oregon, March 3 to August 26.

Mr. John D. Gregson, Liaison Entomologist, Dominion Department of Agriculture, Kamloops, B. C ., June 4 to July 25.

Cpl. Ernest Hackney, Army Field Aid, on detached service from 57th Station Medical Group, Ft. Richardson, Alaska, May 24 to September 24.

Pfc. Dean D. Hesketh, Army Field Aid, on detached service from 57th Station Medical Group, Ft. Richardson, Alaska, June 28 to August 1.

Sgt. Austin J. Hicks, Army Field Aid, on detached service from 580th Engineers, Ft. Richardson, Alaska, May 19 to August 24.

Sgt. J. R. Hill, Ft. Richardson, Alaska, Plane Crew Chief as needed during season.

Pfc. Nick Hoffman, Army Field Aid, on detached service from 183rd General Hospital, Ft. Richardson, Alaska, May 7 to September 13.

Mr. C. N. Husman, Equipment Engineer, USDA, BEPQ, Kerrville, Texas, March 3 to August 26.

Mr. George L. Hutton, Entomologist, Office of the Chief of Engineers, Washington, D. C., April 24 to June 22.

Cpl. Gene Jefferson, Army Field Aid on detached service from Arctic Aero-Medical Laboratory, Ladd Field, Fairbanks, Alaska, May 1 to September 1.

Pfc. Harold E. Kent, Army Field Aid, on detached service from 57th Station Medical Group, Ft. Richardson, Alaska, June 28 to August 1.

Capt. L. E. Larsen, Ft. Richardson, Alaska, Pilot as needed during season.

Father Ernest LePage, Botanist (College of Agriculture, Rimousky, Province of Quebec, Canada), OQMG, Environmental Protection Section, Washington, D.C., May 18 to July 26.

Mr. Siegfried E. Lienk, Entomologist (Graduate student from University of Illinois), USDA, BEPQ, March 31 to September 21.

Mr. Edwin P. Marks, Entomologist (Graduate student from University of Kansas), USDA, BEPQ, March 31 to August 26.

Cpl. Robert E. Melin, Army Field Aid on detached service from Arctic Aero-Medical Laboratory, Ladd Field, Fairbanks, Alaska, August 1 to September 1.

Cpl. Billy Morris, Army Weather Observer, on detached service from 7th Weather Group, Ft. Richardson, Alaska, March 22 to September 24.

Lt. L. O. Nelson, Ft. Richardson, Alaska, Pilot as needed during season.

Mr. Gordon E. Nielsen, Entomologist (Graduate student from the University of Iowa), USDA, BEPQ, March 31 to September 8.

Pfc. Lyle W. Nielsen, Army Field Aid on detached service from 183rd General Hospital, Ft. Richardson, Alaska, April 13 to September 3.

Miss Marguerite Pomeroy, Laboratory Technician, Anchorage, Alaska, April 5 to July 10.

Mr. Richard L. Pratt, Climatologist, OQMG, Environmental Protection Section, Climatic Research Laboratory, Lawrence, Mass., March 10 to August 26.

Sgt. Mickey Ridenour, Army Field Aid, on detached service from 183rd General Hospital, Ft. Richardson, Alaska, March 13 to October 27.

Cpl. Robert L. Rittgers, Army Field Aid, on detached service from 57th Station Medical Group, Ft. Richardson, Alaska, June 28 to August 1.

Dr. Reece I. Sailer, Entomologist, USDA, BEPQ, Washington, D. C., March 31 to September 24.

Pfc. Pete Schulick, Army Field Aid, on detached service from 57th Station Medical Group, Ft. Richardson, Alaska, June 28 to August 1.

Mr. David A. Sleeper, Aquatic Biologist (Graduate student from Stanford, Calif.), USDA, BEPQ, April 14 to August 26.

Dr. C. N. Smith, Entomologist, USDA, BEPQ, Orlando, Fla., June 25 to August 2.

Mr. Nelson Smith, Entomologist Field Aid, USDA, BEPQ, Orlando, Fla., March 3 to August 28.

Dr. Kathryn Sommerman, Entomologist, Army Medical and Graduate School, Walter Reed General Hospital, Washington, D. C., March 31 to October 27.

Pfc. Charles O. Stockman, Army Field Aid on detached service from 183rd General Hospital, Ft. Richardson, Alaska, May 7 to August 23.

Sgt. Carl Sweeney, Army Field Aid, on detached service from 183rd General Hospital, Ft. Richardson, Alaska, May 7 to September 15.

Dr. B. V. Travis, Entomologist in Charge, USDA, BEPQ, Orlando, Fla., March 3 August 28.

Pfc. Duane Wyatt, Army Field Aid, on detached service from 183rd General Hospital, Ft. Richardson, Alaska, May 7 to September 13.

Visitors

Dr. F. C. Bishopp, Entomologist, Assistant Chief, Bureau of Entomology and Plant Quarantine, USDA, BEPQ, Washington, D. C., July 17 to 31.

Dr. J. C. Haldeman, U. S. Public Health Service.

Dr. E. F. Knipling, Entomologist, Chief, Division of Insects Affecting Man and Animals, USDA, BEPQ, Washington, D. C., June 5 to 21.

Dr. H. A. Whittaker, School of Public Health, University of Minnesota, Minneapolis, Minn., August 19.